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Observations of Near-Bottom Flow in a Wave-Dominated Nearshore Environment

by

J.J. Fredericks, John H. Trowbridge, Yogesh C. Agrawal

February 1994

Technical Report

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under Grant No. N00014-92-J-12300.

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Observations of Near-Bottom Flow in a Wave-Dominated Nearshore Environment

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George V. Frisk

George V. Frisk, Chair
Applied Ocean Physics & Engineering Department

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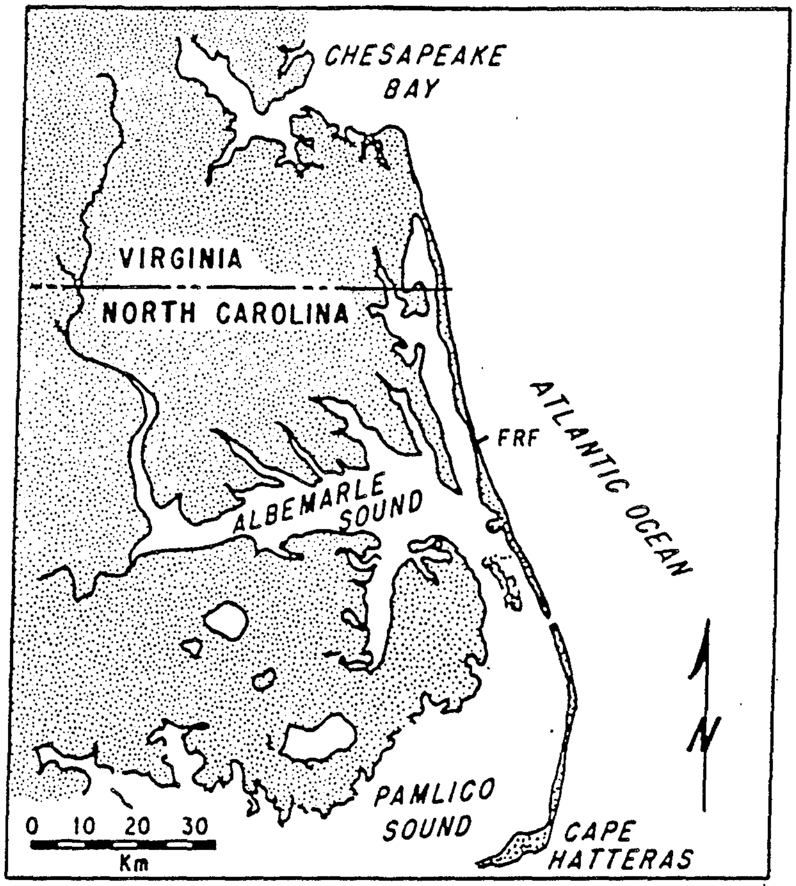


Figure 1. The experiment was conducted December 4-6, 1992, at the Field Research Facility (FRF), off the coast of North Carolina.

1. INTRODUCTION

The near-bottom flow in the wave-dominated nearshore environment is not well understood. Primarily because of constraints on instrumentation, high-quality nearshore field measurements of velocity have been limited for the most part to the region ten or more centimeters above bottom (e.g., Guza and Thornton [1]; Hanes and Huntley [2]; Hanes [3]). Near-bottom flow is important because it controls the entrainment of sediment from the bed and the motion of the sediment in the water column. It may be the site of a significant amount of energy dissipation over beaches. The nearshore near-bottom flow is complicated by the presence of an erodible sand boundary and by the variety of fluid motions that occur in the water column. The unresolved scientific issues include: (1) the influence of heavy concentrations of moving sediment on a fluid flow; (2) the interaction of the near-bottom flow with wave-formed sand ripples; (3) the characteristics of an unsteady boundary layer forced by fluid motions with a broad range of frequencies; and, (4) the effect of turbulence generated by wave breaking.

Observational data of near-bottom flow were collected by the deployment of a bottom-mounted tripod containing a profiling laser-Doppler velocimeter (LDV), a benthic acoustic stress sensor (BASS), a pressure sensor and a video camera. The small sampling volume of the LDV (1mm) permitted unobstructed measurements closer to the bottom than has previously been possible. The data presented in this report are measurements of the near-bottom flow at a site seaward of the surf zone over a sand beach off the coast of North Carolina. (See Figure 1.) The LDV profiled horizontal velocity (cm/s) at 6 elevations from the sea-bed to 16 centimeters above bottom. A pressure sensor simultaneously recorded pressure at 1.26 meters above bottom. The accompanying BASS recorded horizontal and vertical velocity (cm/s) at approximately 20 centimeters above bottom.

The primary scientific objectives of this experiment were to determine: (1) the near-bottom vertical structure of the low-frequency (tidal and sub-tidal) along-shore flow, (2) the near-bottom vertical structure of the mean wave-driven cross-shore flow, (3) the signature of the wave boundary layer, and (4) the characteristics of the near-bottom velocity spectra at high frequencies.

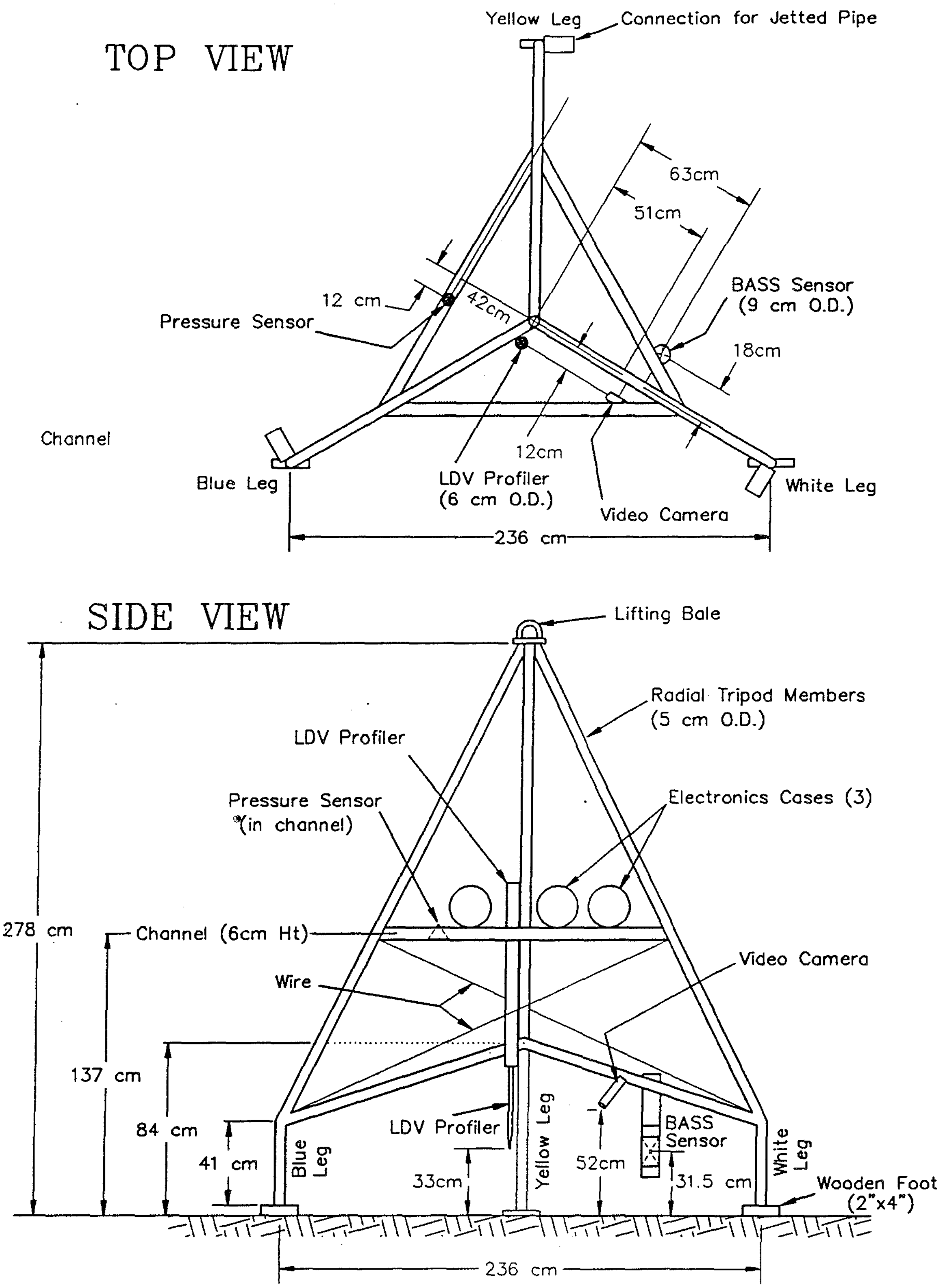


Figure 2. Instrumentation of the tripod. Heights are relative to the deck. Upon deployment, the divers oriented the tripod placing the white leg pointing toward magnetic north. (Drawn to scale.)

2. INSTRUMENTATION

A 278 centimeter tripod (Figure 2) was constructed to withstand surfzone conditions. It was mounted on three 2"x 4" boards with color-coded markings for orientation. The tripod was also rigged with connections for jetting pipes into the sea-bed to secure the tripod. A channel surrounding the perimeter of the tripod served as a platform for the battery and the electronics for the LDV, BASS and pressure sensor.

The tripod was equipped with a downward looking laser Doppler velocimeter (LDV) sampling at 25 Hz. (See Figure 2.) The LDV is a fiber-optic backscatter sensor and was constructed at Quest Inc.* For a detailed description of the LDV and its use in the nearshore environment, see Agrawal and Belting [4] and Agrawal and Aubrey [5], respectively. The sensor, which used a 100mW gallium-aluminum arsenide laser, was mounted on a mechanical profiling mechanism which moved the sensor distances defined by an operator upon deployment. The measured height above deck for the LDV sensor, while in its home position, is the distance from the bottom of a water-filled snout, which was placed on the LDV to stabilize the signal in heavy sediment concentrations.

To provide wave data, the LDV was accompanied by a pressure sensor sampling at 25Hz. This Synsym pressure transducer (ST2015G2) was mounted on the channel as shown in Figure 2.

The benthic acoustic stress sensor (BASS) was used to measure horizontal and vertical velocity components at 10 Hz. It was developed at the Woods Hole Oceanographic Institution by A.J. Williams, 3rd (Williams, et.al. [6]). See Appendix B-1 for more details.

A video camera was added to provide continuous visual images, which provided information about the elevation of the bottom, the presence of kelp and other obstructions, and the presence or absence of bottom ripples.

* Yogesh C. Agrawal was associated with Quest, Inc. and has subsequently become an associate of NorthWest Research Associates.

3. FIELD DEPLOYMENT

The tripod was deployed off the coast of Cape Hatteras, North Carolina, on December 3, 1992, at the Field Research Facility (FRF) of the U.S. Army Engineer Waterways Experiment Station (WES), Coastal Engineering Research Center (CERC). Logistical support was excellent and the area was well surveyed and documented (Howd, et.al [7]). The tripod was carried aboard the amphibious vehicle, R/V LARC, to the deployment site which was 609.6 meters off-shore and 56.4 meters north of the pier (Figure 3). The 5.9 meter depth of the water column below NGVD (National Geodetic Vertical Datum) was determined by the profile run by the U.S. Army Corps of Engineers on December, 2, 1992 (see Figure 4). The electronic cables were brought to the pier, where the microprocessor used to monitor the data collection was housed.

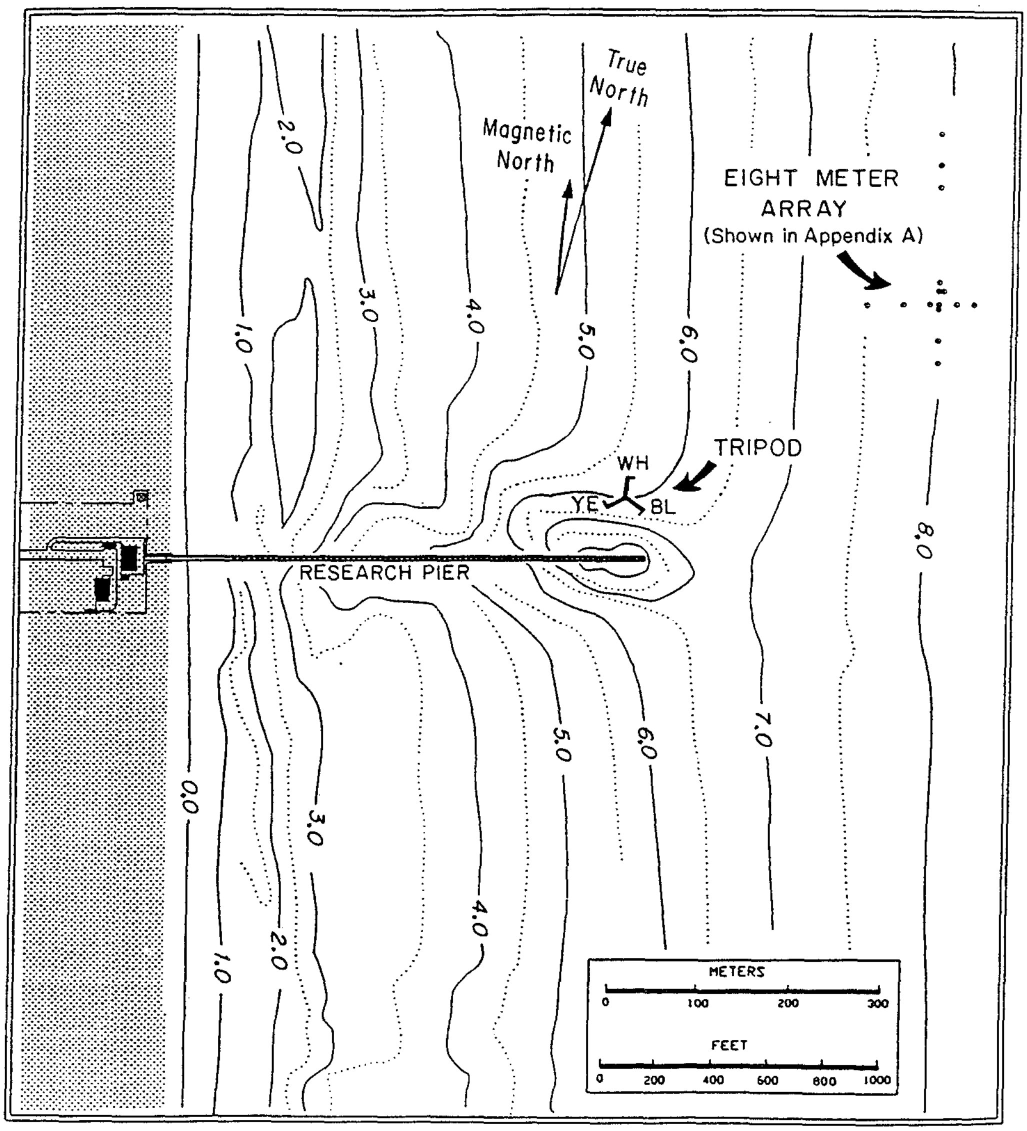


Figure 3. Deployment of the tripod was 56.4 meters north of the pier and 609.6 meters from the onshore base.

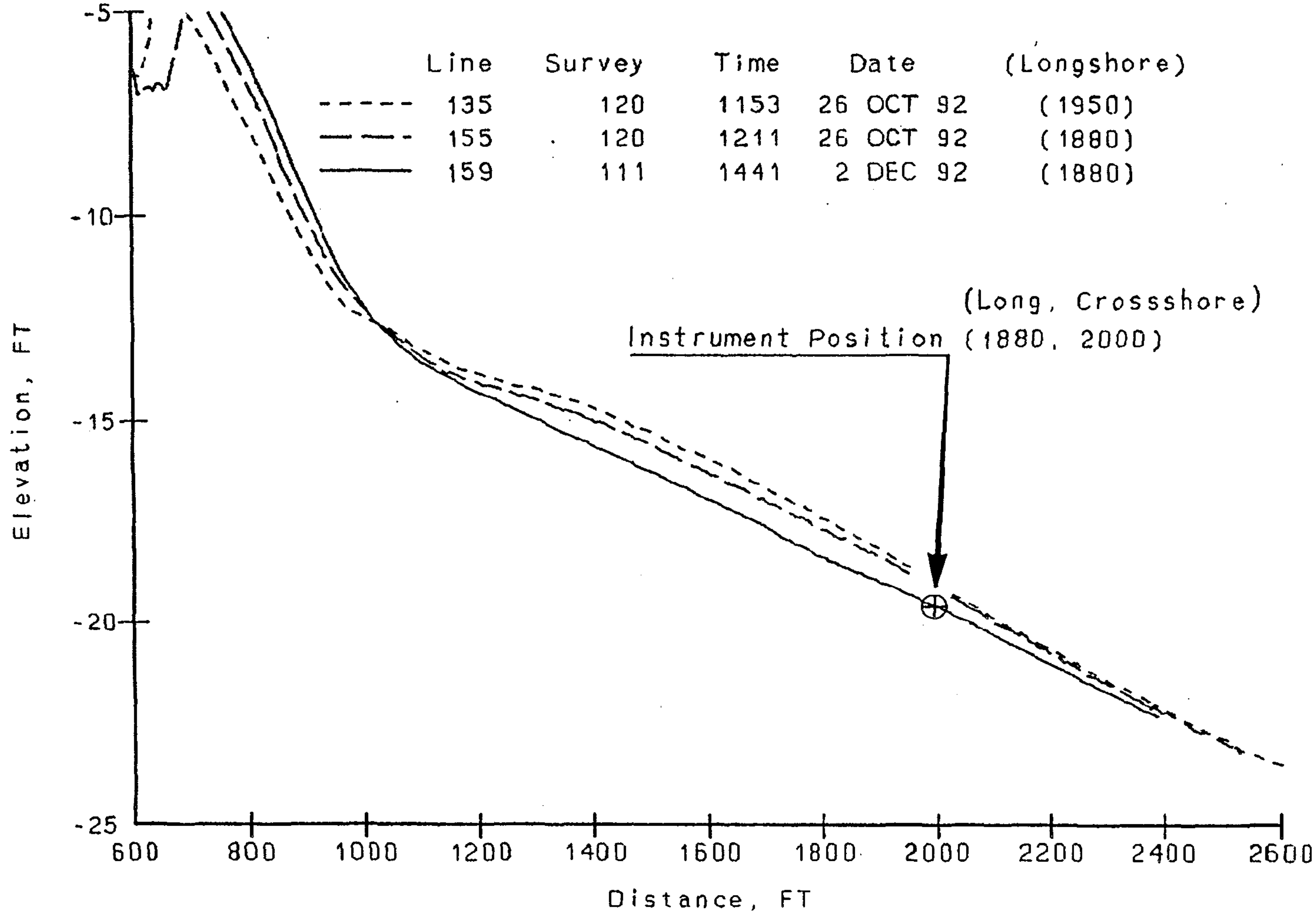


Figure 4. Depth Profile from U.S. Army Corp of Engineers. Instrument Position (1880,2000) was noted in feet and is relative to positions as described in Howd, et. al. (1987). These can be converted to meters as follows: 1) The pier is at 1695'. Therefore, the instrument is (1880-1695)feet or 56.4 meters north of the pier. The instrument is 2000 feet or 609.6 meters from the onshore base. The depth at the "Instrument Position" can be taken from the plot as 5.9 meters.

The LDV was mounted on a profiling mechanism which moved the LDV to specific sampling heights. To determine the location of the bottom, a procedure referred to as a "bottom-find" was conducted. First, the LDV was brought to the "home position". It was then stepped downward until a strong reflectance was observed, which was assumed to be the bottom. The number of steps from the home position to the determined bottom is called the T-value. This procedure was repeated throughout the experiment and the results are listed in Table 1. The distances (cm) were converted from the corresponding steps using the conversion factor of 2.992 centimeters per 1000 steps. The LDV was stepped to the bottom, and then it was moved off the bottom and sampled as follows:

eid	Δz (steps)	Δz (cm)	z (cm)
1 & 7	n	0.5	0.5
2 & 8	n	0.5	1
3 & 9	2n	1	2
4 & 10	4n	2	4
5 & 11	8n	4	8
6 & 12	16n	8	16

where Δz is the distance the profiler moves in steps (n = 167 steps) or cm; and z is the height of the sample volume at each elevation id (eid). The software monitored the position of the LDV sensor, relative to the "home position". The sensor was brought to the bottom-most sampling elevation; then, a signal was issued by an operator to commence sampling. After each 90 second observation, the profiler stepped to the next elevation, cycling through (0.5 -> 16cm above bottom) twice. This provided twelve 90 second "snapshots". The LDV components (in counts) were stored with the pressure signal (in counts) and a time stamp as twelve 90-second, 25 Hz binary records. The format is described in **bin2mat.c** (See Appendix B.) The BASS was concurrently measuring velocity components at 10 Hz. The BASS clock was not set, but relative time values were stored with each 90-second ASCII velocity record.

Each set of twelve 90-second records is identified as d2_0NN, where NN is a number between 16 and 83. The data prior to d2_016 is not presented in this report, as they were used for testing and parameter definition. Table 1 summarizes the data collection with observed environmental conditions and field notes.

A collection of the wind and wave directional spectra were provided by the U.S. Army Corps of Engineers and can be found in Appendix A.

Series ID	Start Time da:hr:mn	T-Value steps-cm	Notes
	04:12:15		Divers lowered tripod ~4" (10cm) to bring LDV sampling volume closer to the bottom which brought the height of the LDV snout (in home position) to 8" (20.3 cm) above bottom. Bottom of BASS cage was measured at 1.5" (3.8cm) above bottom. The video camera position was adjusted slightly.
			Bottom Find/Reset #1
d2_016	04:14:41	7000-20.9	
d2_017	04:15:05	7000-20.9	
d2_018	04:15:31	7000-20.9	
d2_019	04:15:53	7000-20.9	During d2_016-35: winds were fairly strong and persistently from the SW. There was swell from the east propagating onshore. Period appeared to be approximately 5 seconds and height was approximately .5 meters. Bottom could be seen on video until 16:30 or so. Early on, the bottom was fairly clear and appeared to have ripples with a wavelength of 1/3 the field of view or approximately 10cm. Sometimes, ripples were shorter.
d2_020	04:16:25	7000-20.9	
d2_021	04:16:46	7000-20.9	
d2_022	04:17:08	7000-20.9	
d2_023	04:17:28	7000-20.9	
d2_024	04:17:50	7000-20.9	
d2_025	04:18:13	7000-20.9	
d2_026	04:18:35	7000-20.9	
d2_027	04:18:56	7000-20.9	
d2_028	04:19:17	7000-20.9	
d2_029	04:19:39	7000-20.9	
d2_030	04:20:00	7000-20.9	
d2_031	04:20:21	7000-20.9	
d2_032	04:20:42	7000-20.9	
d2_033	04:21:03	7000-20.9	
d2_034	04:21:25	7000-20.9	
d2_035	04:21:46	7000-20.9	
			Bottom Find/Reset #2
d2_036	05:14:25	6120-18.3	
d2_037	05:14:46	6120-18.3	
d2_038	05:15:08	6120-18.3	Ripples on bottom: long-crested with crests roughly NW; approximately 10 ripples in field of view. Bottom hard to see because of sand in water.
d2_039	05:15:29	6120-18.3	
d2_040	05:15:50	6120-18.3	
d2_041	05:16:11	6120-18.3	
d2_042	05:16:33	6120-18.3	
d2_043	05:16:54	6120-18.3	During d2_036-83: Strong wind from NW, shifting to N; Large Seas/swell from NE
d2_044	05:17:15	6120-18.3	
			Bottom Find-No Reset #3 T-Value was 6460(18.9cm) T-Value was left as 6120 in software.
d2_045	05:17:44	6120-18.3	
d2_046	05:18:08	6120-18.3	
d2_047	05:18:29	6120-18.3	
d2_048	05:18:51	6120-18.3	
d2_049	05:19:13	6120-18.3	
d2_050	05:19:34	6120-18.3	
d2_051	05:19:56	6120-18.3	

Table 1.

Series ID	Start Time da:hr:mn	T-Value steps-cm	Notes
d2_052	05:20:17	6120-18.3	
d2_053	05:20:38	6120-18.3	
d2_054	05:21:00	6120-18.3	
	05:21:21		Bottom Find/Reset #4 Apparent problem in Bottom Find: moved 8850 steps to home position. Did bottom find three times with 7300 result.
d2_055	05:22:34	7300-21.8	
d2_056	05:22:55	7300-21.8	
d2_057	05:23:16	7300-21.8	
d2_058	05:23:38	7300-21.8	
d2_059	05:23:59	7300-21.8	
d2_060	06:00:20	7300-21.8	
d2_061	06:00:41	7300-21.8	
d2_062	06:01:02	7300-21.8	
d2_063	06:01:23	7300-21.8	
d2_064	06:01:44	7300-21.8	
d2_065	06:02:05	7300-21.8	BASS data record missing.
d2_066	06:02:26	7300-21.8	
d2_067	06:02:47	7300-21.8	
d2_068	06:03:08	7300-21.8	
d2_069	06:03:29	7300-21.8	
d2_070	06:03:50	7300-21.8	
	06:04:12		Bottom Find/Reset #5
d2_071	06:04:17	7080-21.2	
d2_072	06:04:39	7080-21.2	
d2_073	06:05:00	7080-21.2	
d2_074	06:05:21	7080-21.2	
d2_075	06:05:44	7080-21.2	
d2_076	06:06:53	7080-21.2	
d2_077	06:07:12	7080-21.2	
d2_078	06:07:34	7080-21.2	
d2_079	06:07:57	7080-21.2	
d2_080	06:08:18	7080-21.2	
d2_081	06:08:40	7080-21.2	
d2_082	06:09:02	7080-21.2	
d2_083	06:09:23	7080-21.2	
	06:09:44		Bottom Find #6: moved 6925 steps to home Bottom find at approximately 7300 (21.8 cm).
	06:10:30		Diver measured heights of instruments before recovery: Bottom of BASS cage at 3.25" (8.2cm), Bottom of LDV in top-most position at 6.375"(16cm). (But found on recovery that LDV was NOT in home-position).
	06:10:55		After recovery: Bottom of BASS Cage was 19cm above deck, Bottom of LDV was 33cm above deck in home position (with snout in place).

Table 1 (continued)

As seen in Figure 3, the shoreline (along-shelf isobath) is oriented 20° from True North. The horizontal components of the BASS were aligned as closely as possible to Magnetic North (which is -10° from True North). (See Figure 5.)

The bottom-find data and the divers' measurements indicate at least an eleven (11) centimeter sink. This is in agreement with the deployment log, as a tripod is expected to sink about two centimeters and, as noted in Table 1, the divers then lowered the tripod another 4" (10cm) by working the feet back and forth in the sand. This would place the center of the BASS sampling volume and the sampling volume of the LDV (when in home-position) at approximately 21 cm above bottom. (See Figure 6.)

While at the FRF facilities, the BASS was enclosed in a water-filled plastic bag and recorded for 90 seconds at 10HZ to provide the post-deployment zeros, as shown in Section 4.

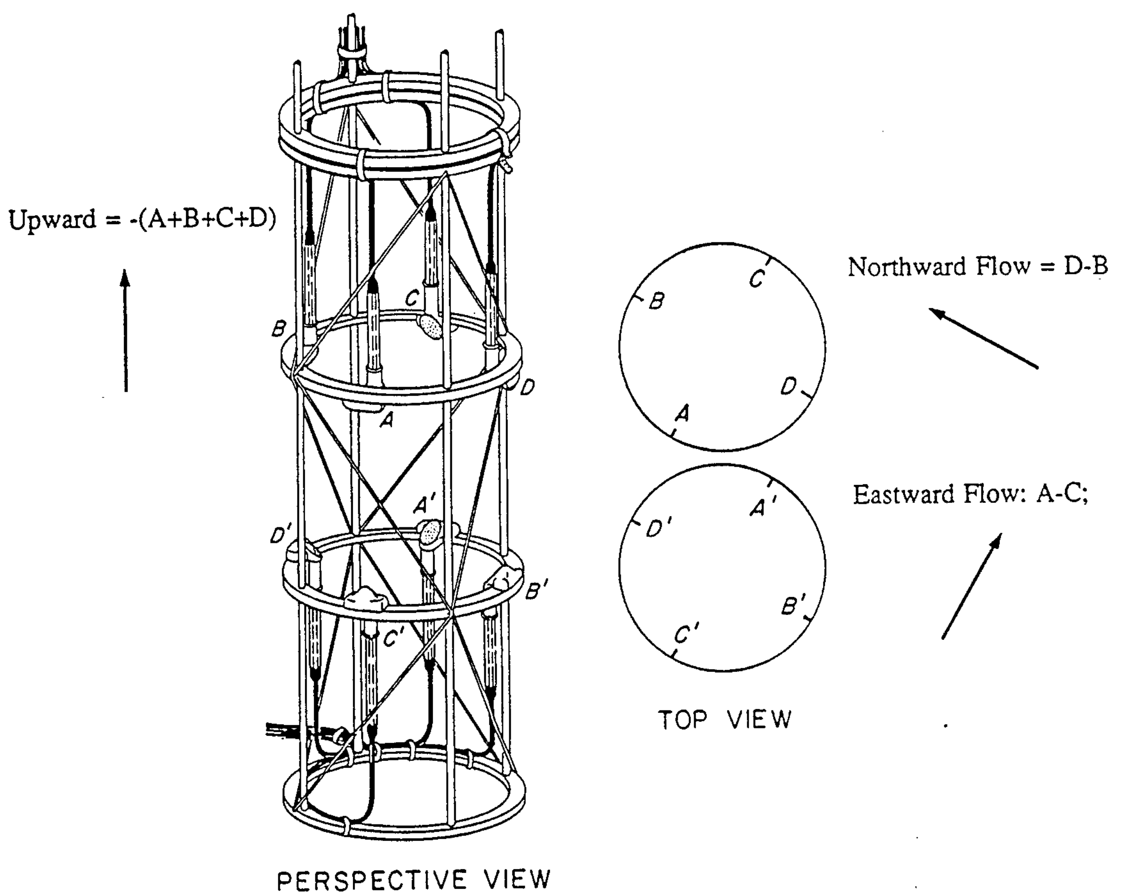


Figure 5. The D-B Axis of the BASS was aligned parallel with the 'white' tripod leg. The tripod was oriented with the 'white' foot heading Magnetic North. The BASS cage was on the Western side of the tripod leg. (See Figure 2.)

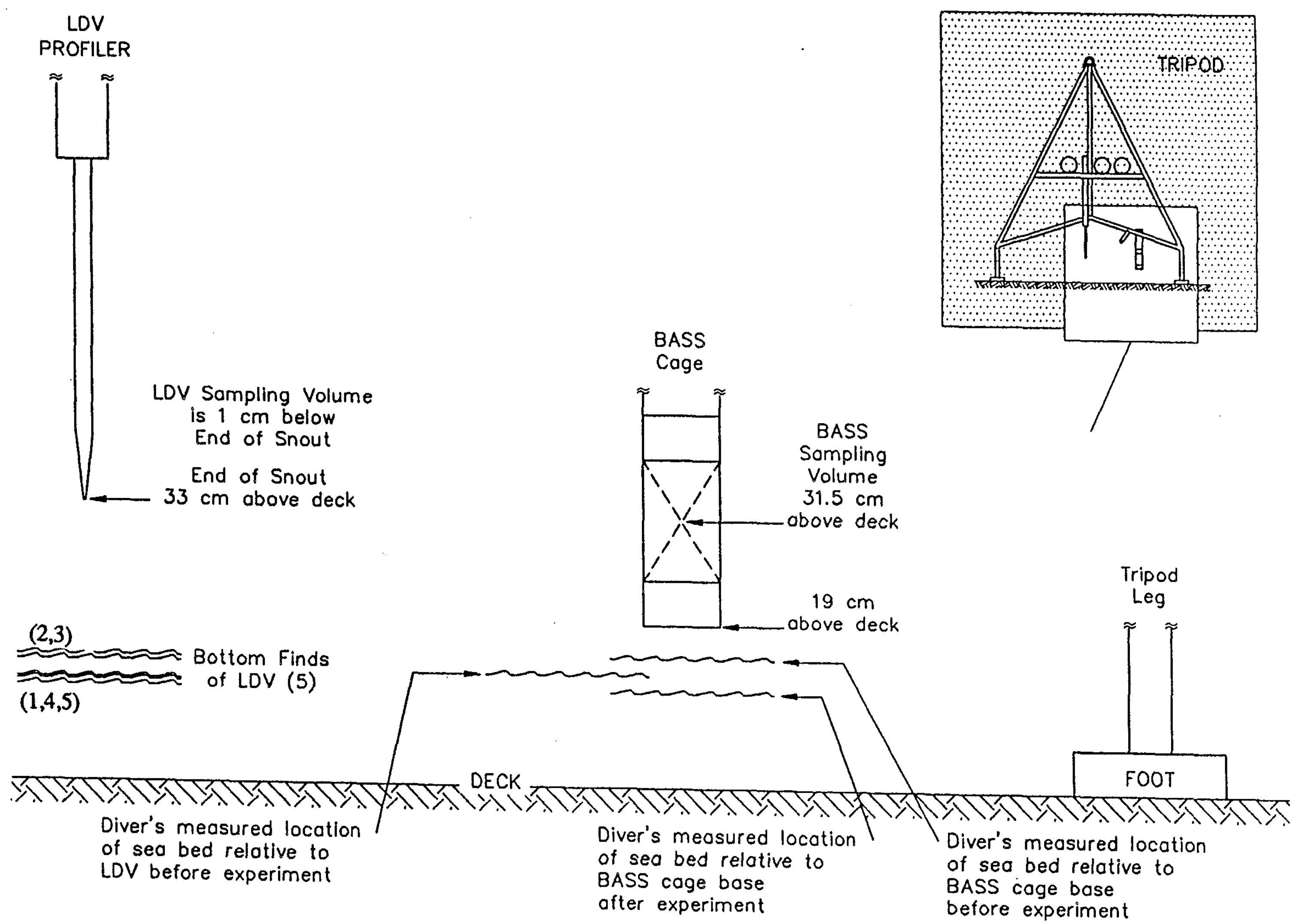


Figure 6. Sea bed estimates are relative to BASS cage and LDV snout (in home position) and LDV profiler bottom-finds. Using the longest distances of these estimates, the bottom of the tripod was lowered into the sea bed by atleast 11 centimeters. (Drawn to scale.)

4. DATA PROCESSING

The binary LDV/pressure records were processed using the program **bin2mat.c** (see Appendix B). The program converted the binary files to MATLAB® files, converting the LDV and pressure counts to centimeters/sec and meters of saltwater, respectively. The offset used in converting the LDV counts to cm/s was determined by observing the signal during periods when no velocity component was apparent at the 0.5 cm elevation. During those periods, the signal clustered along a velocity which was taken to be a zero offset. The North-South (NS) LDV count was subtracted from a 129 count zero offset and then a 0.375 counts per cm/s gain factor was applied. The E-W data were processed separately (see below). The pressure was converted from 16 bit to 12 bit by dividing by 16. The counts were then converted to meters above the sensor by applying a gain factor of 520 meters/count. A 1.035 conversion factor was used to convert from the fresh-water calibration to salt-water conditions.

The LDV data were combined with the BASS data using the routine **joinlb.m.** (See Appendix B.) The pressure was further modified in **joinlb.m** by the addition of a 1.0 meter offset. This addition was necessary to correlate the pressure with the NOAA/NOS concurrent tide data (Section 6.1) and was indirectly verified by the comparison of the spectral density profiles of surface waves (Section 5.1).

The velocity outliers were identified as points which were 3.5 times the standard deviation from the mean of the 90 second record. The outliers were replaced with an interpolated value which resulted from a spline fit through the data without the outliers. This procedure continued through five iterations or until no more outliers were found, whichever occurred first. As shown in Figure 7, the peaks of strong, deviant waves have been slightly modified using this processing technique. Figure 8 shows the result of this processing on a typical LDV record. The BASS data usually contained very few outliers, although a few records contained as much as 6% flagged as outliers due to peak wave modification, as described above. Although most of the NS-LDV outliers were removed, some were within the tolerance of the definition of an outlier and remain in the data. In most cases, the amount of data removed was less than 6%, with the exception of the bottom-most elevations when the velocity remained about zero and vacillations were flagged as outliers. At those elevations, as much as 14% were flagged as outliers. The EW-LDV data were processed separately, as described below.

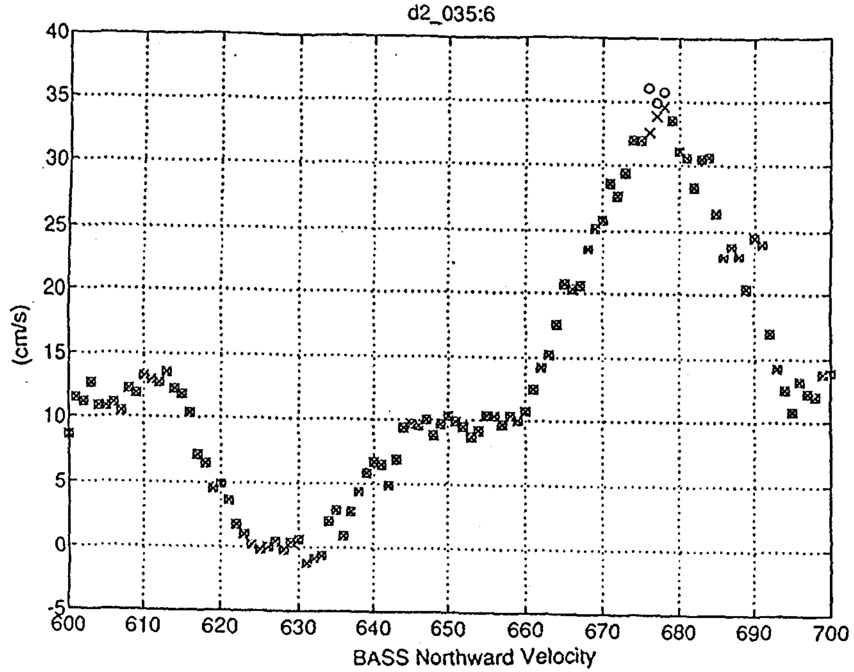


Figure 7. Affect of Removing BASS Outliers on Velocity Peaks (o - preprocessed points and (×) - processed points)

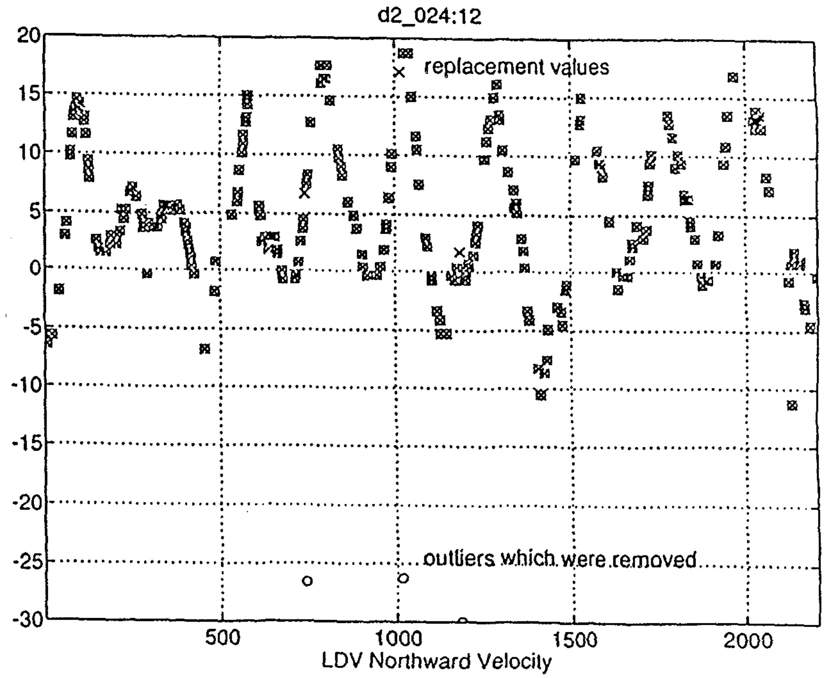


Figure 8. Example of LDV Outliers Removed in Processing (o - preprocessed points and (×) - processed points)

The routine **joinlb.m** also converts the BASS data to 25 Hz by using MATLAB functions to interpolate from 10Hz to 50 Hz and run a finite impulse response decimation to 25Hz. Figures 9 and 10 show the results of the process on a randomly selected record.

Post-deployment zeros (Figure 11) were removed from the BASS data and converted from corrected counts to cm/s as described in **joinlb.m.** The calibration curve used in determining the gain factor is included as Figure 12. Based on the size of the BASS cage and the speed of light (Williams, et al. [6]), the time rate (dt) per velocity unit (dV) can be computed:

$$\frac{dt}{dV} = 1.333\frac{nanoseconds}{(cm/s)}$$

Based on the calibration curve,

$$\frac{dt}{dC} = \frac{400nanoseconds}{5000counts}$$

Therefore, the gain factor in converting counts to velocity can be computed as:

$$\frac{400ns}{5000counts}\,\frac{1cm/s}{1.333ns} = \frac{0.060(cm/s)}{count}$$

Through estimates of phase, an approximate 1.1 second delay between the BASS and the LDV/Pressure records was observed. Hardware analysis of the instruments found an actual 1.09 second delay. Therefore, to shift the BASS in time to be consistent with the LDV, the first 1.09 seconds of the BASS were dropped. To avoid fractional seconds, data were further truncated to 2200 samples (88 seconds) per record. (See **joinlb.m** - Appendix B.)

Each LDV data point was accompanied by a qualifier, or data validation word, for each axis. The data validation word is determined on the basis of two criteria: signal strength and signal quality. When the photocurrent signal is sufficiently strong, and when it is of sufficiently high quality, the highest bit is set to make the validation word reach the magnitude 128. The quality criterion is the acceptable threshold for signal to noise, in the frequency domain, of the photocurrent. The actual time of occurrence within the capture window for each data realization is then appended to make the full validation word. For example, if the data validation word is 230, it implies that the data is valid (having met signal strength and signal-to-noise criteria) and that it occurred at 230-128=102nd fraction of the window width. In processing, epsilon (eps) was added to the qualifier field, vqual, to convert the variable to floating point. This was done to assure system compatibility of the archival files.*

*See MATLAB External Interface Guide, p. 30.

Figure 9. Example of Interpolation and Decimation in Conversion of BASS from 10Hz to 25Hz. (detail)

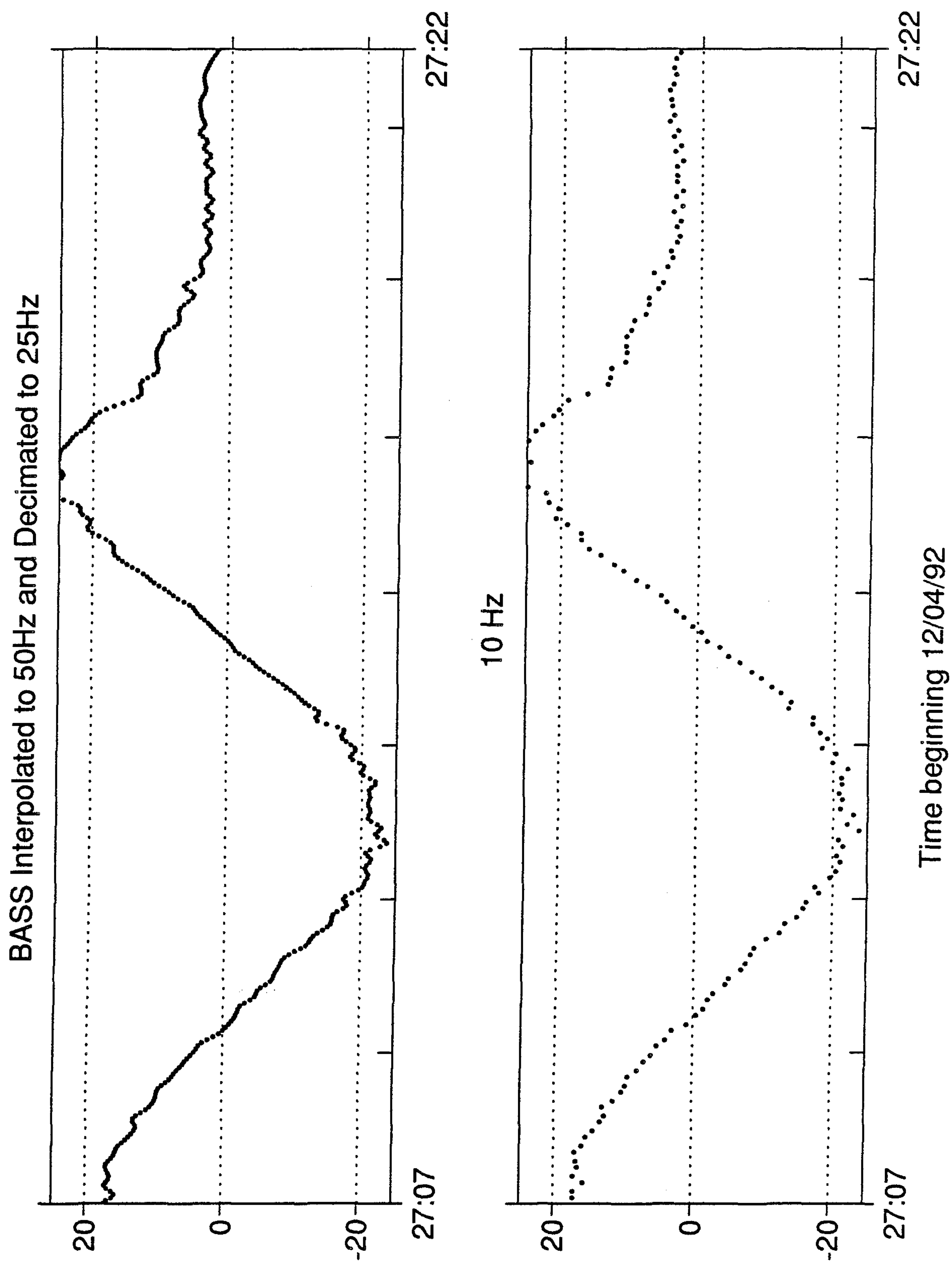


Figure 10. Example of Interpolation and Decimation in Conversion of BASS from 10Hz to 25Hz. (overview)

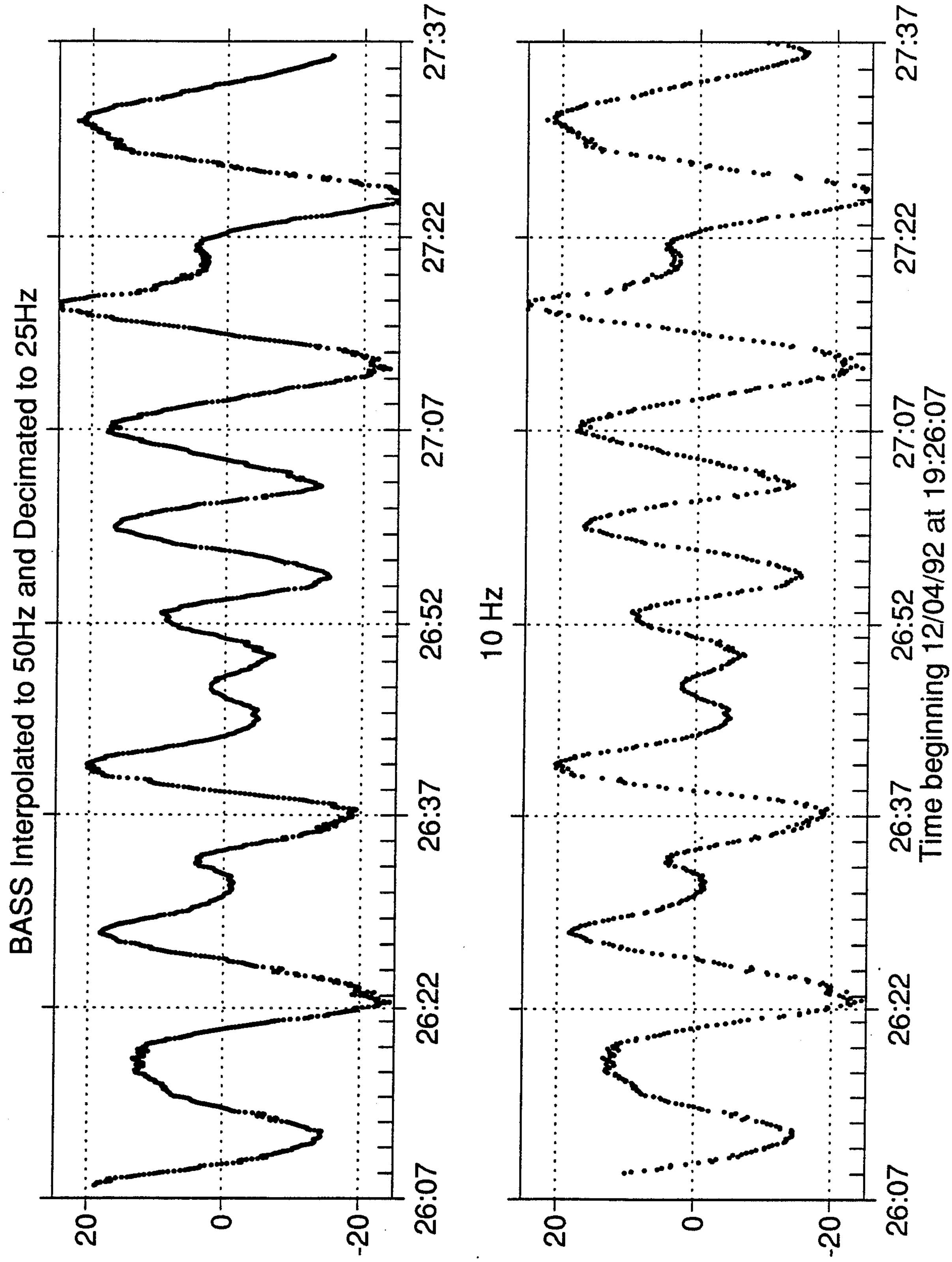
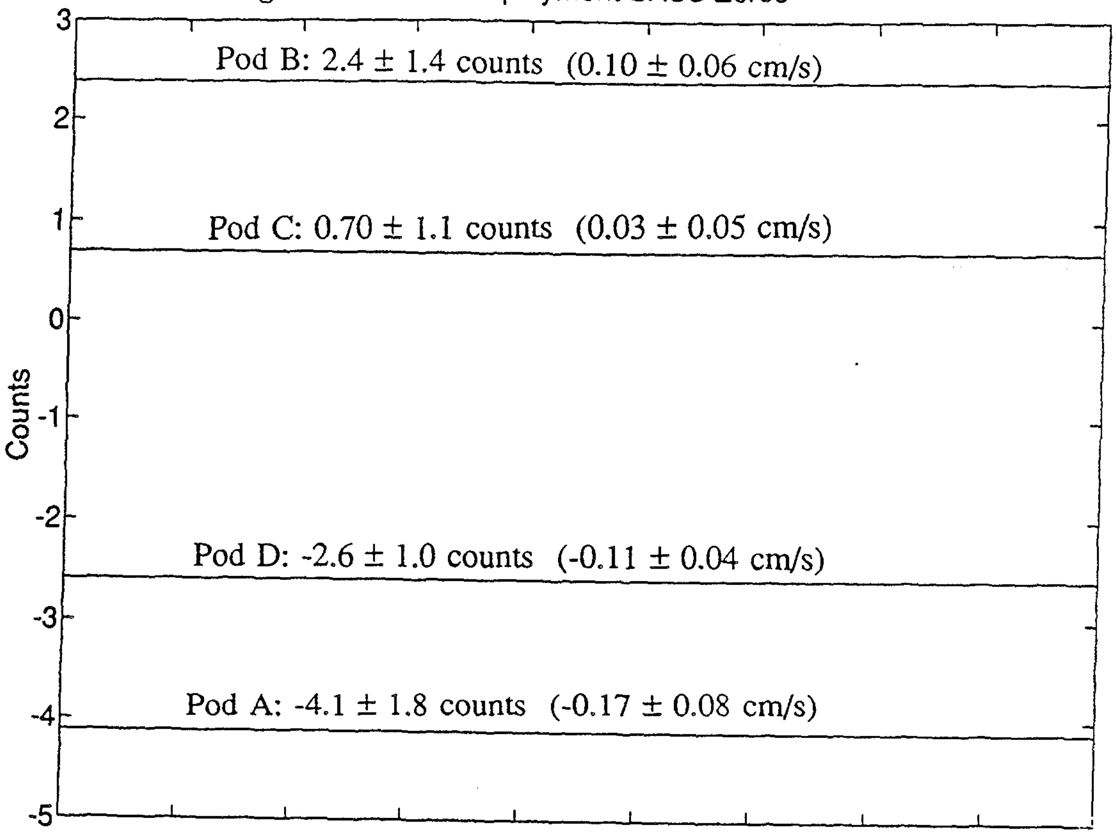
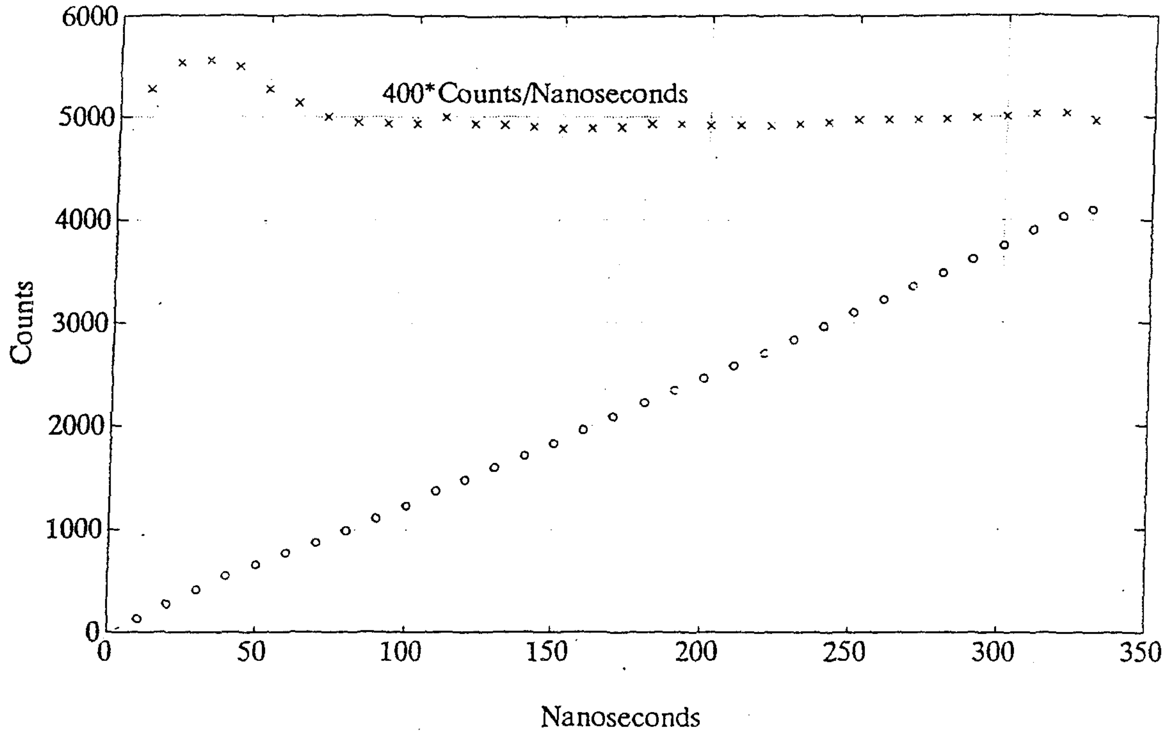


Figure 11. Post-Deployment BASS Zeros



Mean + Standard Deviation Taken Over a 90 Second Record

Figure 12. BASS Calibration Curve



The EW-LDV component failed during most of the experiment (see Figure 13-A). Profiles of the E-W LDV axis could only be retrieved for some of series d2_025 through d2_029. For those profiles, the signal could be determined in the cloud of points which were reported as being valid (see Figure 13-B). These records were processed by fitting a polynomial through sections of a hand-digitized approximation and accepting points within 1cm/s of the polynomial fit (see **pfit4.m** in Appendix B). The counts were converted to cm/s by subtracting a 32 cm/s zero offset and then applying a gain of 1.23 (cm/s). The gain factor was derived by fitting the data to the concurrent EW-BASS data (see Section 5.2.2).

Figure 14 graphically displays the periods during the experiment when measurements were obtained. Each line segment on this figure represents a set of 12 88-second measurements, as explained in Section 2. The numbers associated with the line segments are the series IDs as shown in Table 1. A copy of the figure can provide a useful tool as an overlay for determining areas of study from the time series included throughout the remainder of this report. For the purposes of this report, the sets were grouped in eight hour segments for evaluation and display. The four eight-hour segments are shown in Figure 14. The bounds were chosen solely for the purpose of display, providing eight hour windows. But, the groups were also used to localize statistical analyses, as seen in Section 5. Where appropriate, we have also displayed a super-set of the observations taken between 12/05/92 (14:30) and 12/06/92 (10:00). This group includes sets d2_036 - d2_083 and is plotted in a 20 hour window. Statistical analysis of the super-set was not performed. The program **makeseries.m** computed statistics for the 88-second records of each group (see Appendix B). The program **joinseries.m** concatenated the 88-second records of each group for multi-hour comparison of BASS and LDV (see Appendix B).

Data files are described in Section 7 of this report.

Figure 13-A.

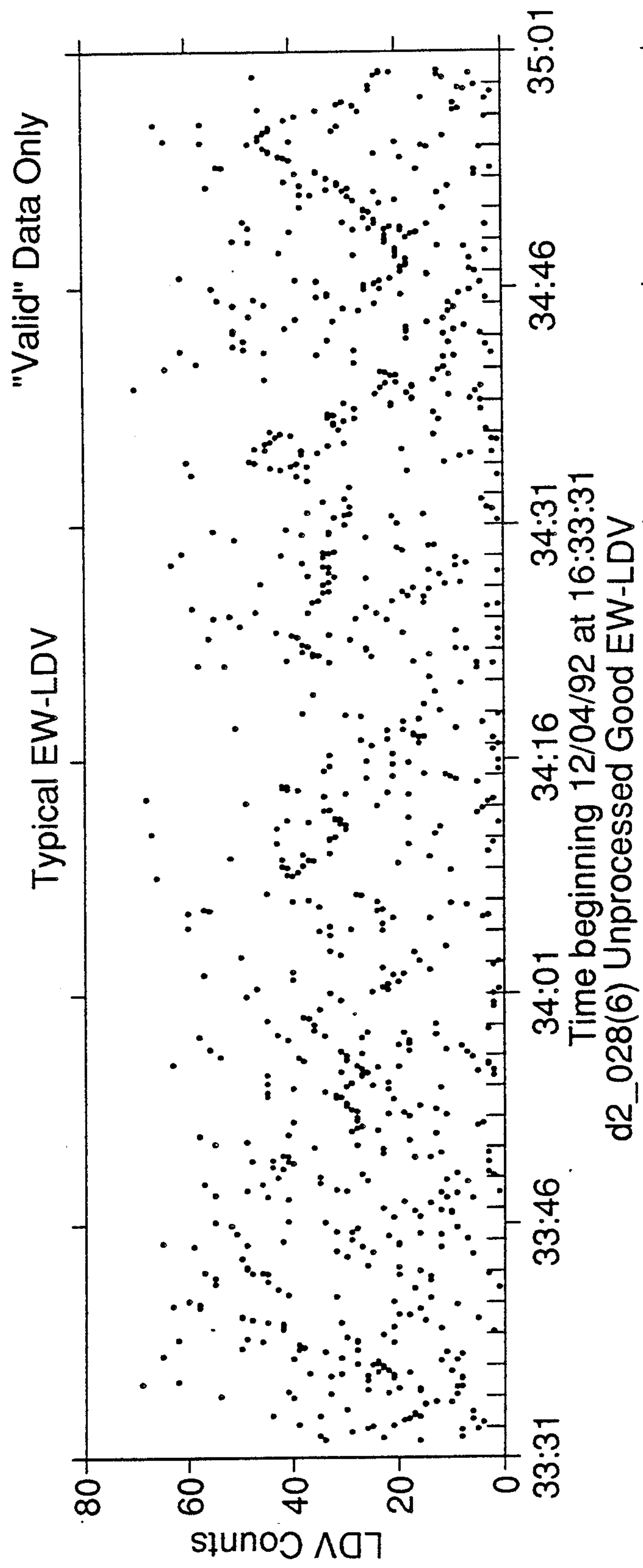


Figure 13-B.

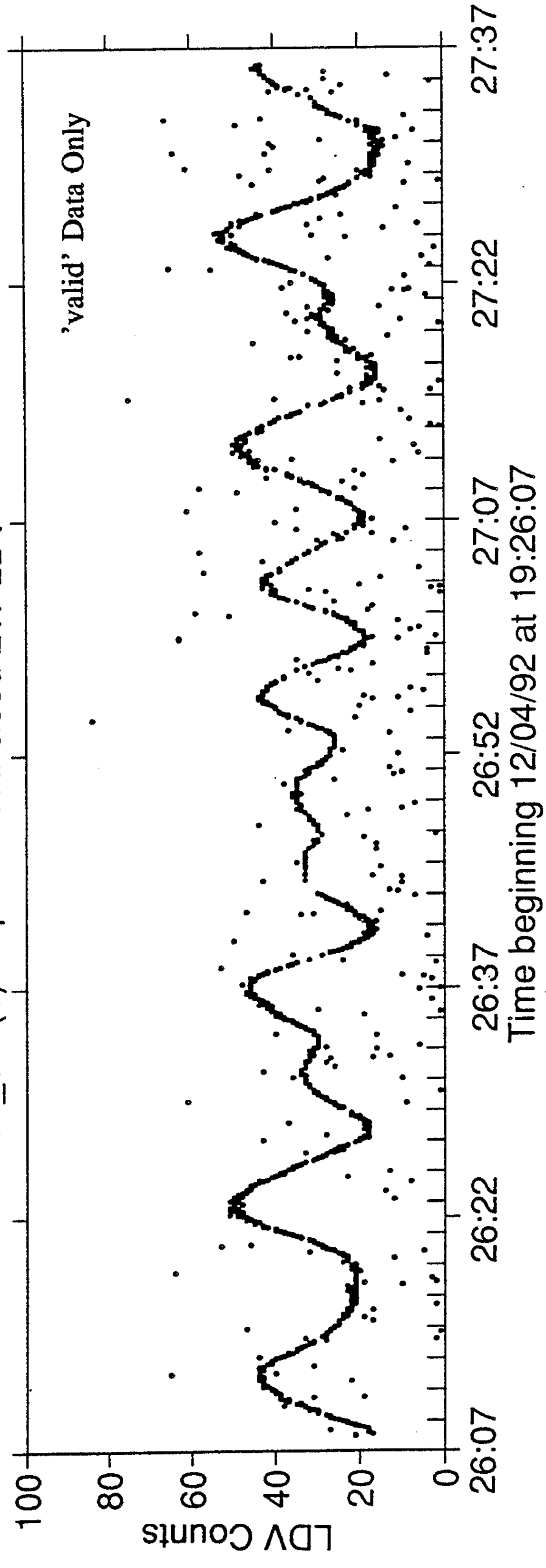
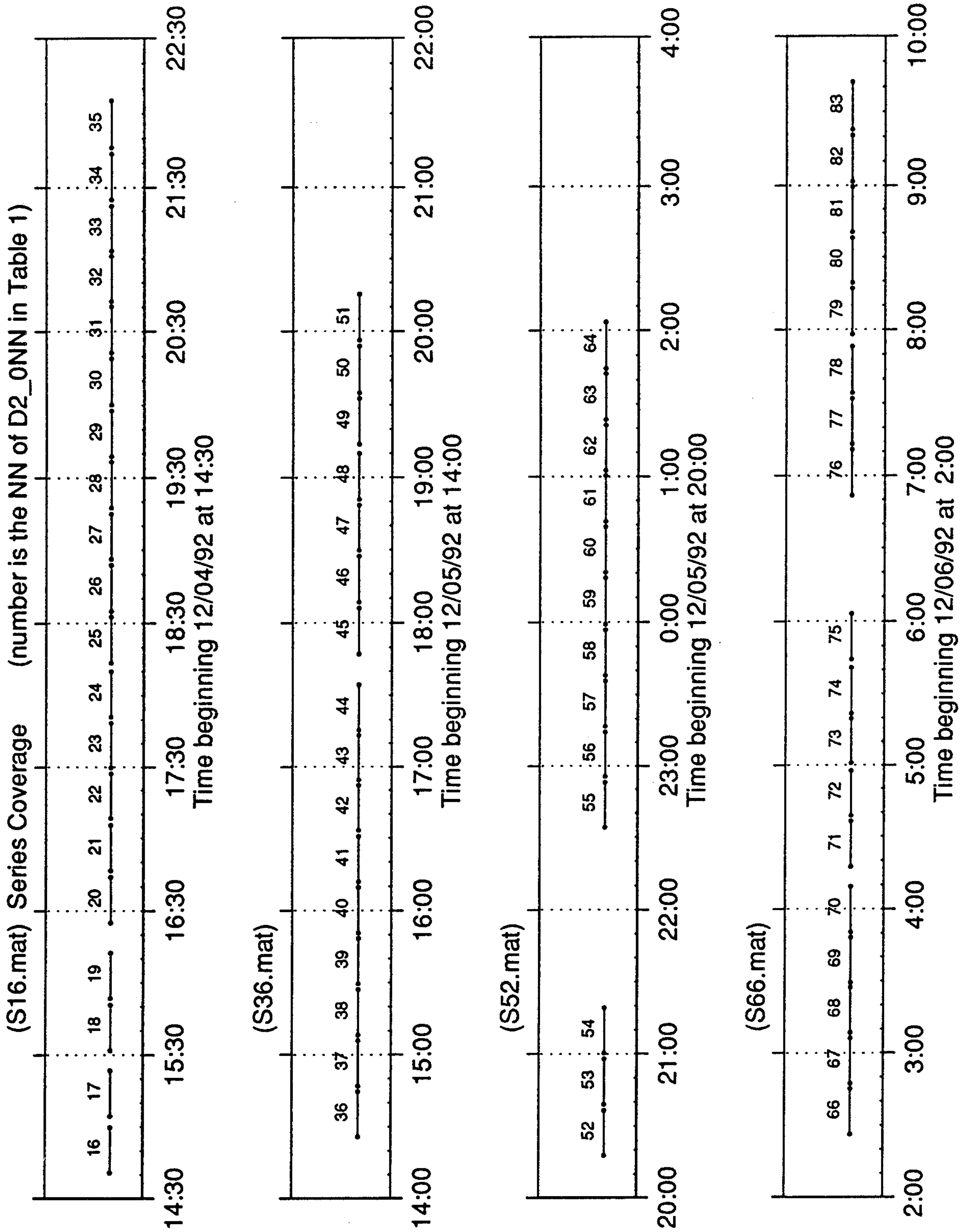


Figure 14. Coverage of Sets and Groups



5. CONSISTENCY CHECKS and BASS/LDV COMPARISONS

5.1 Pressure/BASS Checks

The pressure data were compared to the horizontal (North-South and East-West) BASS components by converting pressure spectra at 1.26 meters above bottom to velocity spectra at 0.21 meters above bottom via linear wave theory (Dean et. al. [8]). First, the surface spectral density was estimated from the pressure spectrum:

$$S_{\eta\eta}(f) = \frac{S_{pp}(f)}{\rho^2 g^2} \frac{\cosh^2(kh)}{\cosh^2[k(z+h)]}$$

where f is the frequency, $S_{\eta\eta}$ is the spectral density of surface displacement (η), S_{pp} is the spectral density of pressure (p) at the height z+h above bottom (1.26 m for pressure), ρ is the density of water, g is gravitational acceleration, h is the water depth as determined from pressure at each record, and k is the wave number which is determined from g, ω and h by

$$\omega^2 = g\, k \tanh(kh)$$

where ω is the radian frequency ($2\pi f$).

Then, from the surface spectral density, the velocity spectra at 0.21 meters above bottom was estimated:

$$S_{uu}(f) + S_{vv}(f) = \omega^2 S_{\eta\eta}(f) \frac{\cosh^2[k(z+h)]}{\sinh^2(kh)}$$

where S_{uu} is the spectral density of EW velocity (u), S_{vv} is the spectral density of NS velocity (v), and z+h is again the height of the sampling volume above bottom (0.21 m for BASS velocity).

As seen in Figures 15-16, a comparison of the observed velocity spectra with the velocity spectra as computed from pressure shows good agreement. Two sets of 12 records (approximately 42 minutes of observation) were averaged for each comparison. The divergence seen between approximately .4 and 5 Hz may represent turbulent velocity fluctuations.

Figures 17-18 confirm a high coherence at energy-containing frequencies between the Westerly BASS component and the pressure. The non-zero phase is not understood.

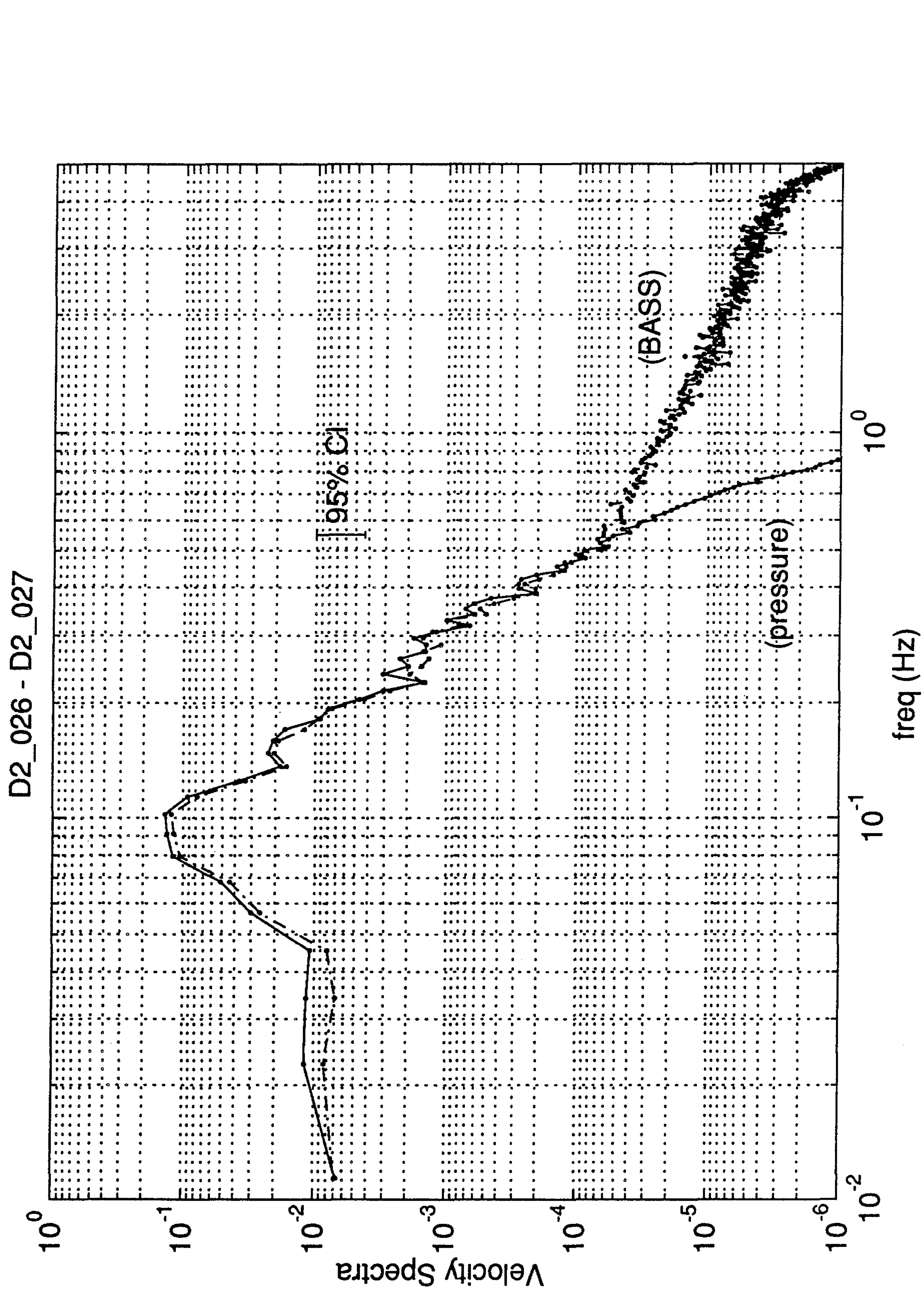

D2_026 - D2_027
Velocity Spectra
freq (Hz)
95% CI
(BASS)
(pressure)
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-2}
10^{-1}
10^{0}

Figure 15.

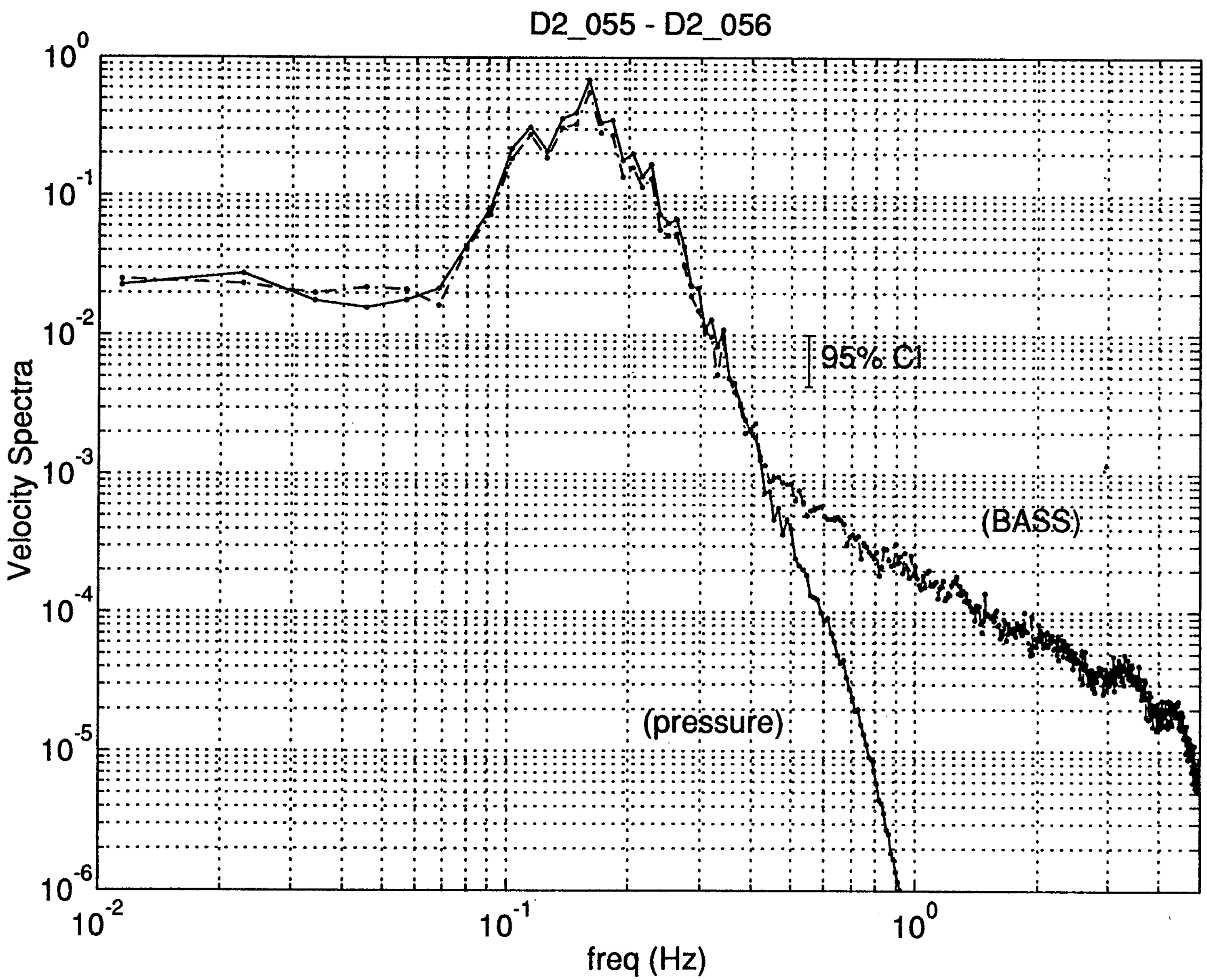

D2_055 - D2_056
Velocity Spectra
freq (Hz)
95% CI
(BASS)
(pressure)
10^0
10^-1
10^-2
10^-3
10^-4
10^-5
10^-6
10^-2
10^-1
10^0

Figure 16.

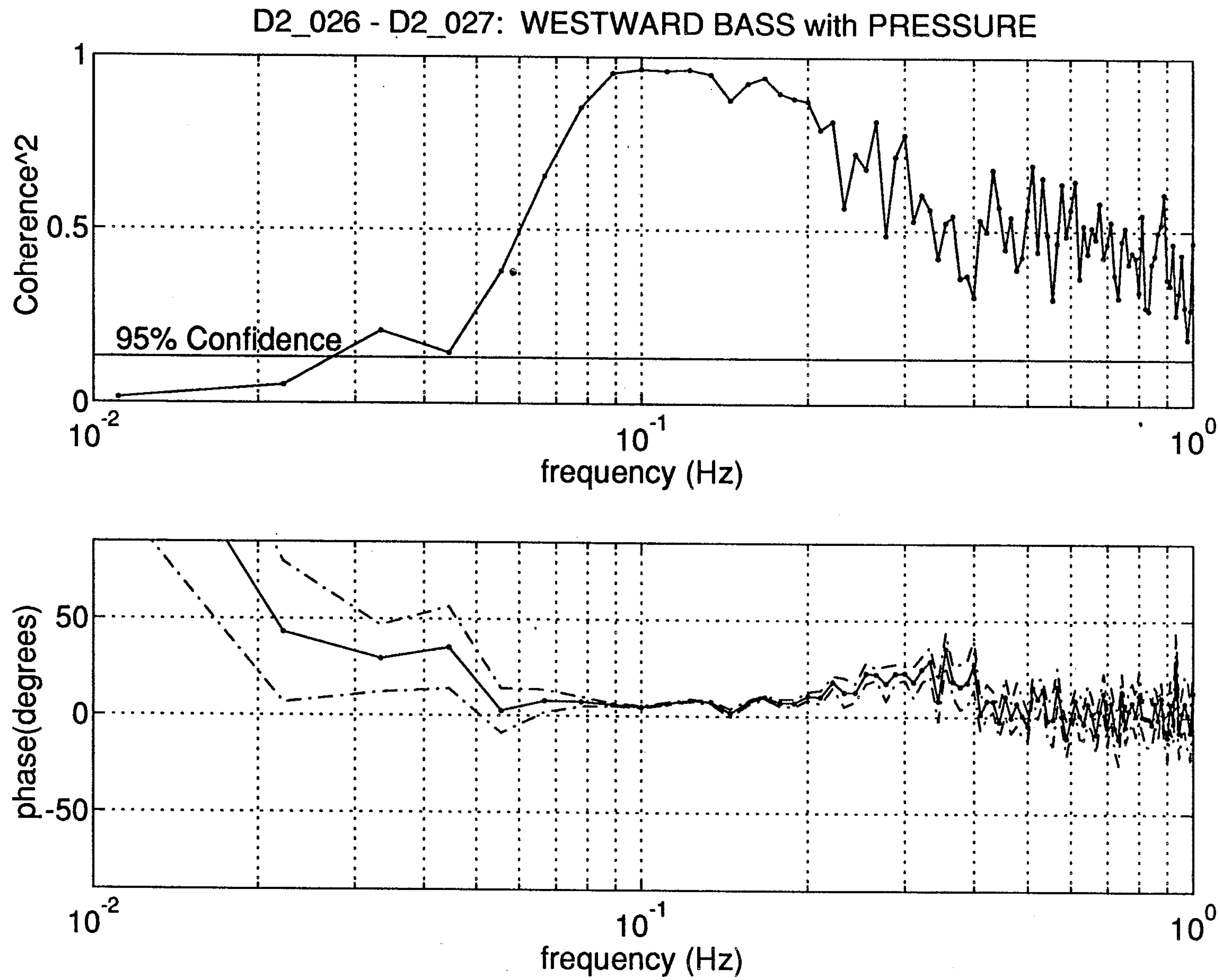

D2_026 - D2_027: WESTWARD BASS with PRESSURE
Coherence^2
1
0.5
0
95% Confidence
10^-2
10^-1
10^0
frequency (Hz)
phase(degrees)
50
0
-50
10^-2
10^-1
10^0
frequency (Hz)

Figure 17.

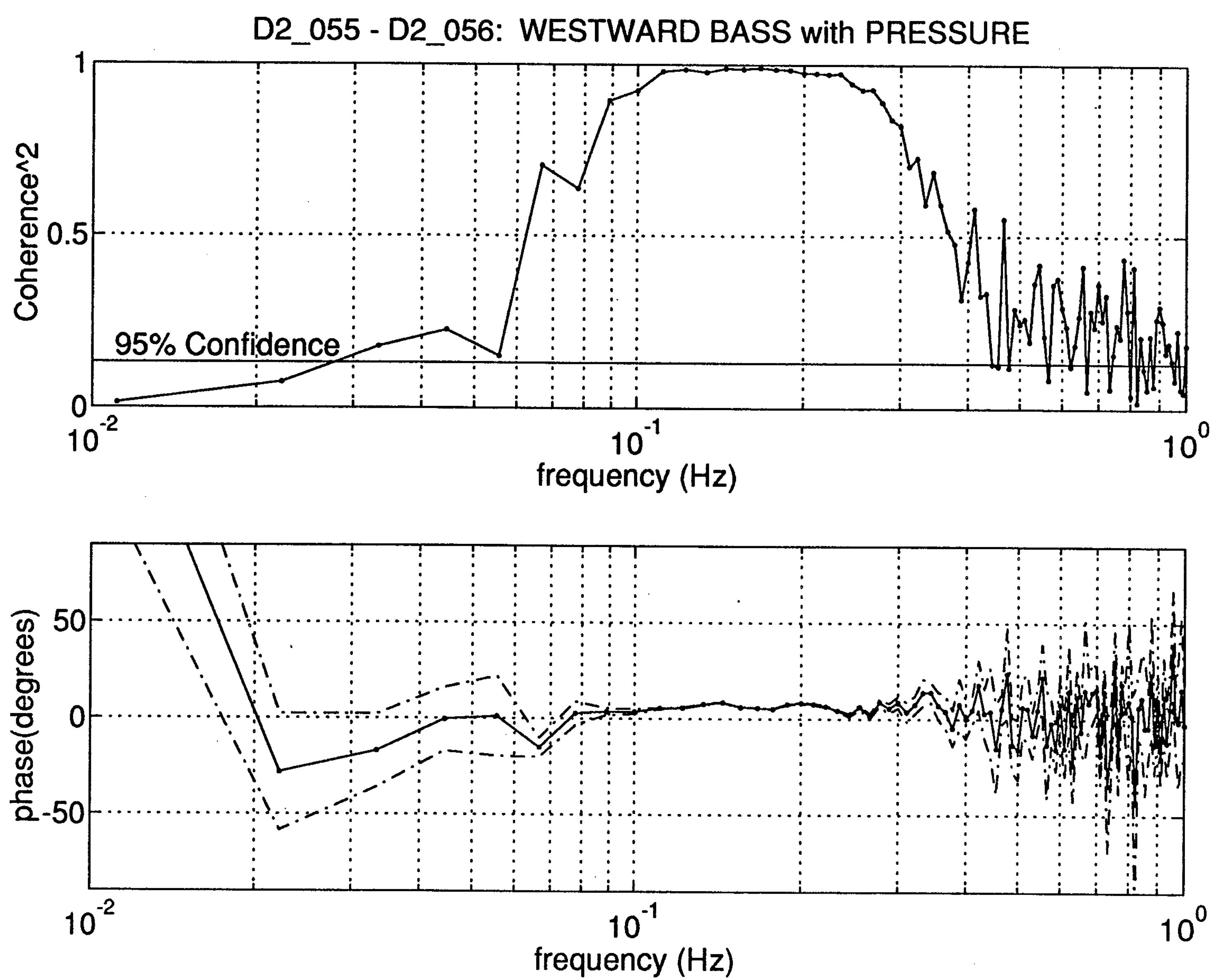

D2_055 - D2_056: WESTWARD BASS with PRESSURE
Coherence^2
1
0.5
0
95% Confidence
10^-2
10^-1
10^0
frequency (Hz)
phase(degrees)
50
0
-50
10^-2
10^-1
10^0
frequency (Hz)

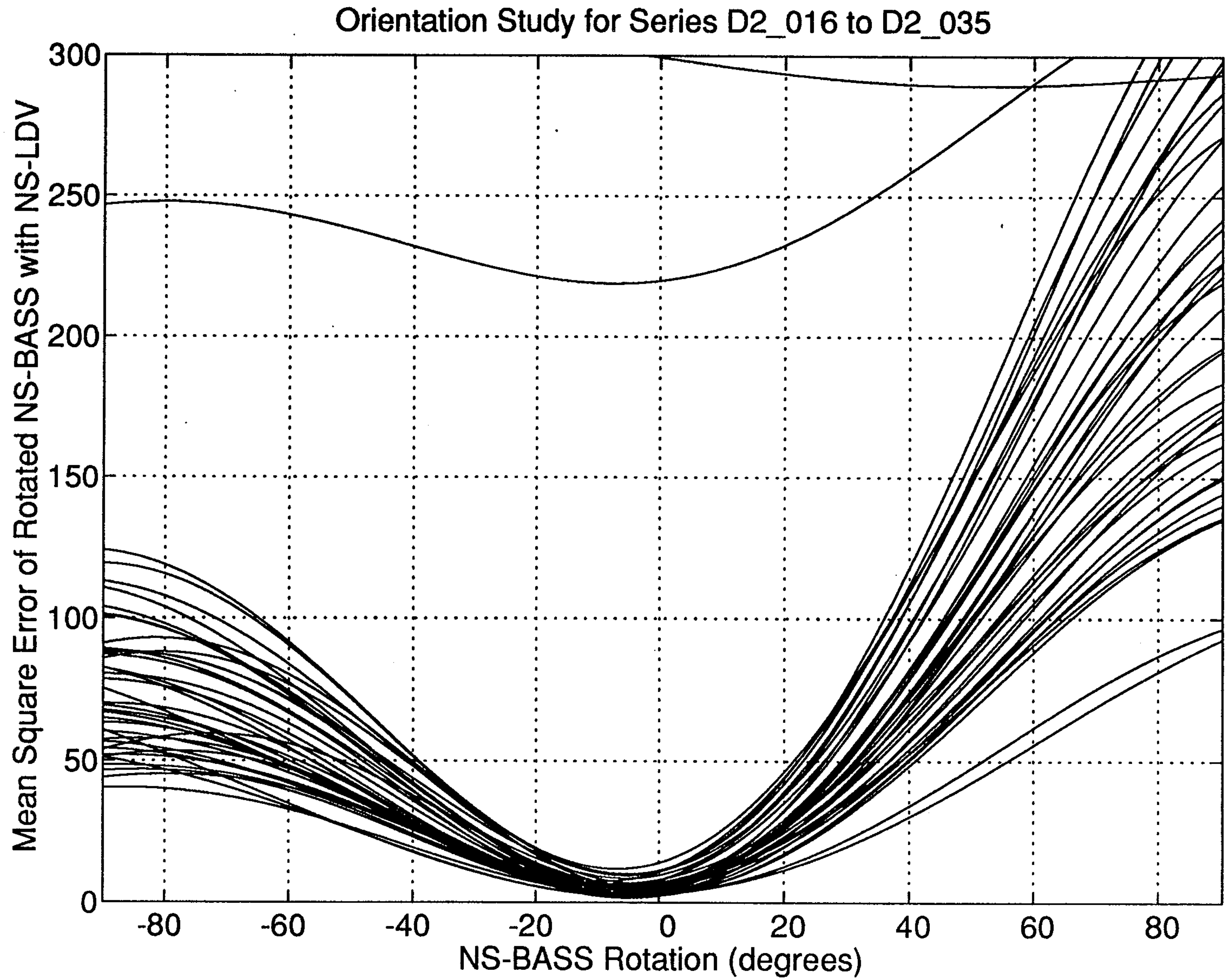
Figure 18.

5.2 NS-BASS/NS-LDV

Since theory indicates that the 16 cm height of the top-most LDV is outside the wave boundary layer, we could expect good agreement at surface wave frequencies when comparing the concurrent BASS with the samples taken when the LDV was profiling at the top-most location. Before comparisons of the BASS with the LDV, the mean was removed because the mean of the near-bottom flow is believed to be strongly sheared, so that differences between means of the BASS and LDV are expected. In this section, we will describe the relative orientation of the BASS and LDV axes, the correlation of the LDV with the BASS, verification of the LDV and BASS gains and the effect of the LDV return rate on the mean velocity.

5.2.1 Orientation

The orientation between the NS-LDV and the NS-BASS was checked by rotating the BASS through 180° (-90° to +90°) and computing a corresponding mean square error for each degree. The mean square error (MSE) was computed by taking the mean of the square of the difference between the NS-LDV and the concurrent rotated BASS (with means removed). Figures 19-22 present the MSE computed at each degree of rotation. In figures 23-26, the angle of orientation at which the minimum MSE was observed, and the corresponding MSE, are plotted for each record (x) and those records having more than 8% valid NS-LDV have a 'o' overlayed. Although each individual record does not indicate clearly what rotation should be used (Figures 23-26), when taken collectively, as shown in Figure 27, a consistent best rotation of approximately -5.4°. appears. The comparisons for d2_066-d2_083 were not included in the histogram as they appeared to have correlation problems other than rotation. In comparison of LDV with BASS, we have rotated the BASS, since the EW-LDV did not consistently produce good data so that rotation of the LDV data is not possible for most of the experiment. We have not rotated the BASS in the data summary section, as we believe this to be the appropriate orientation, with Northward representing Magnetic North. All results indicate that the NS-LDV axis is approximately 5° closer to alignment with the isobaths than is the NS-BASS axis.



Orientation Study for Series D2_016 to D2_035
Mean Square Error of Rotated NS-BASS with NS-LDV
300
250
200
150
100
50
0
-80
-60
-40
-20
0
20
40
60
80
NS-BASS Rotation (degrees)

Figure 19.

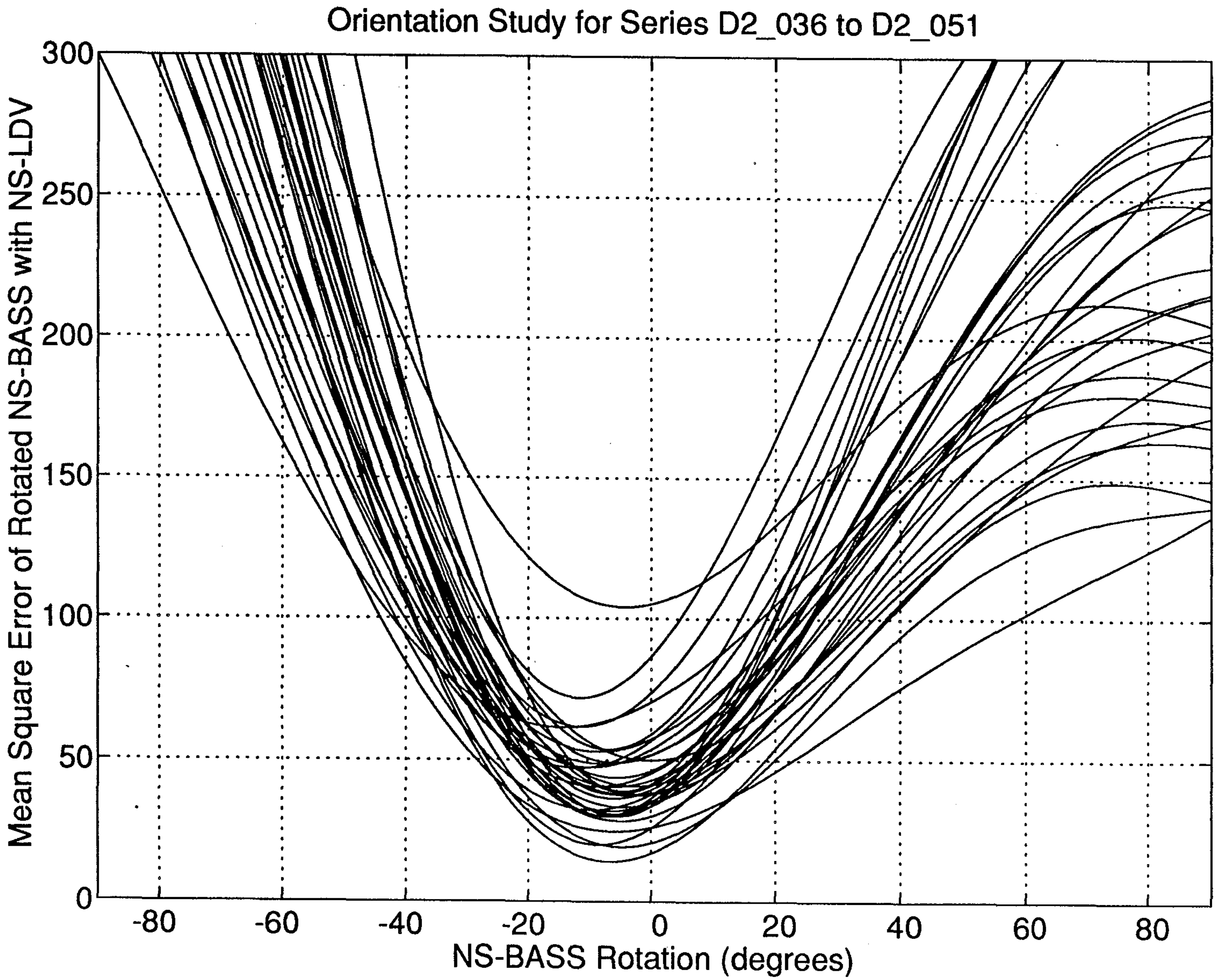

Orientation Study for Series D2_036 to D2_051
Mean Square Error of Rotated NS-BASS with NS-LDV
300
250
200
150
100
50
0
-80
-60
-40
-20
0
20
40
60
80
NS-BASS Rotation (degrees)

Figure 20.

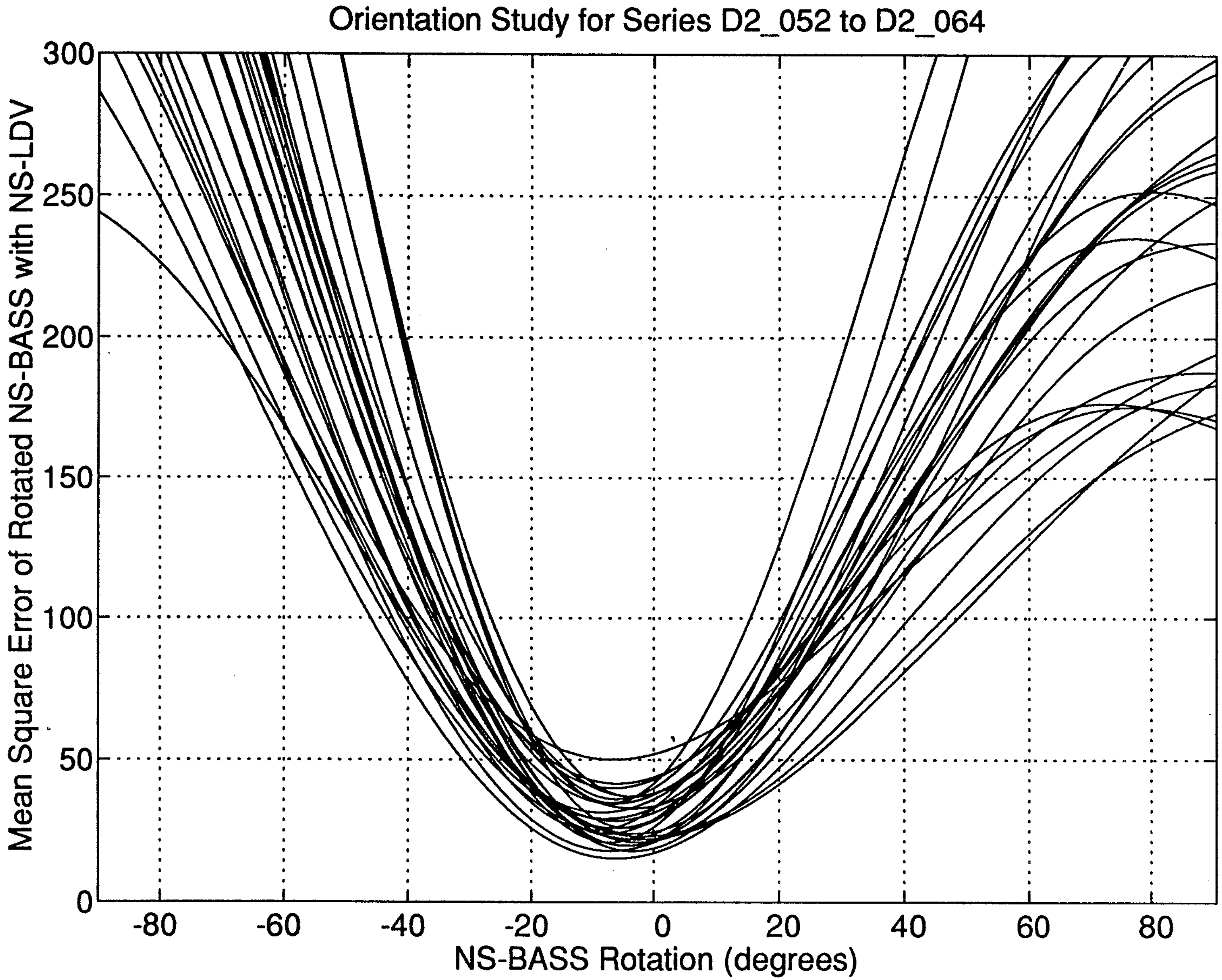

Orientation Study for Series D2_052 to D2_064
Mean Square Error of Rotated NS-BASS with NS-LDV
300
250
200
150
100
50
0
-80
-60
-40
-20
0
20
40
60
80
NS-BASS Rotation (degrees)

Figure 21.

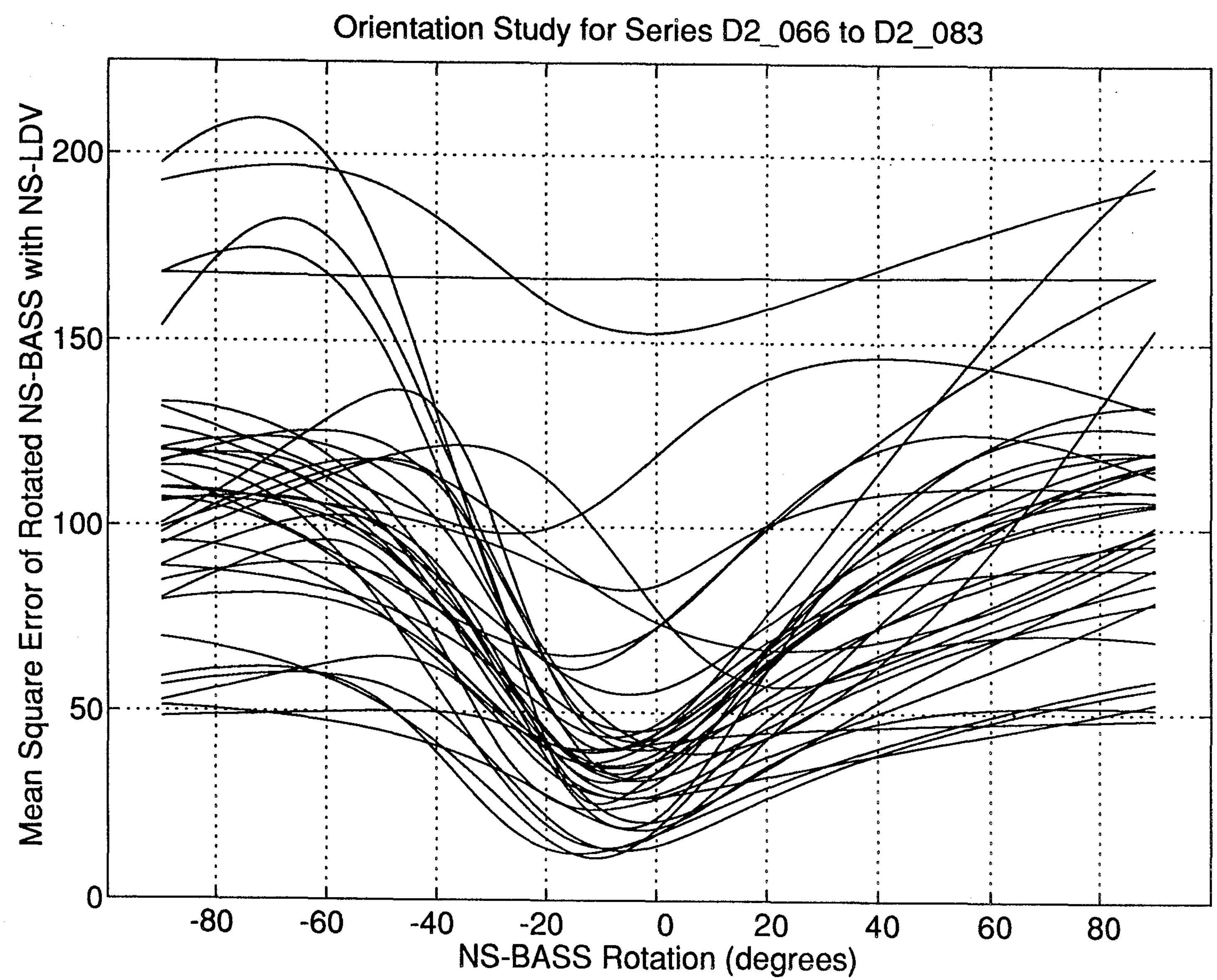

Orientation Study for Series D2_066 to D2_083
Mean Square Error of Rotated NS-BASS with NS-LDV
200
150
100
50
0
-80
-60
-40
-20
0
20
40
60
80
NS-BASS Rotation (degrees)

Figure 22.

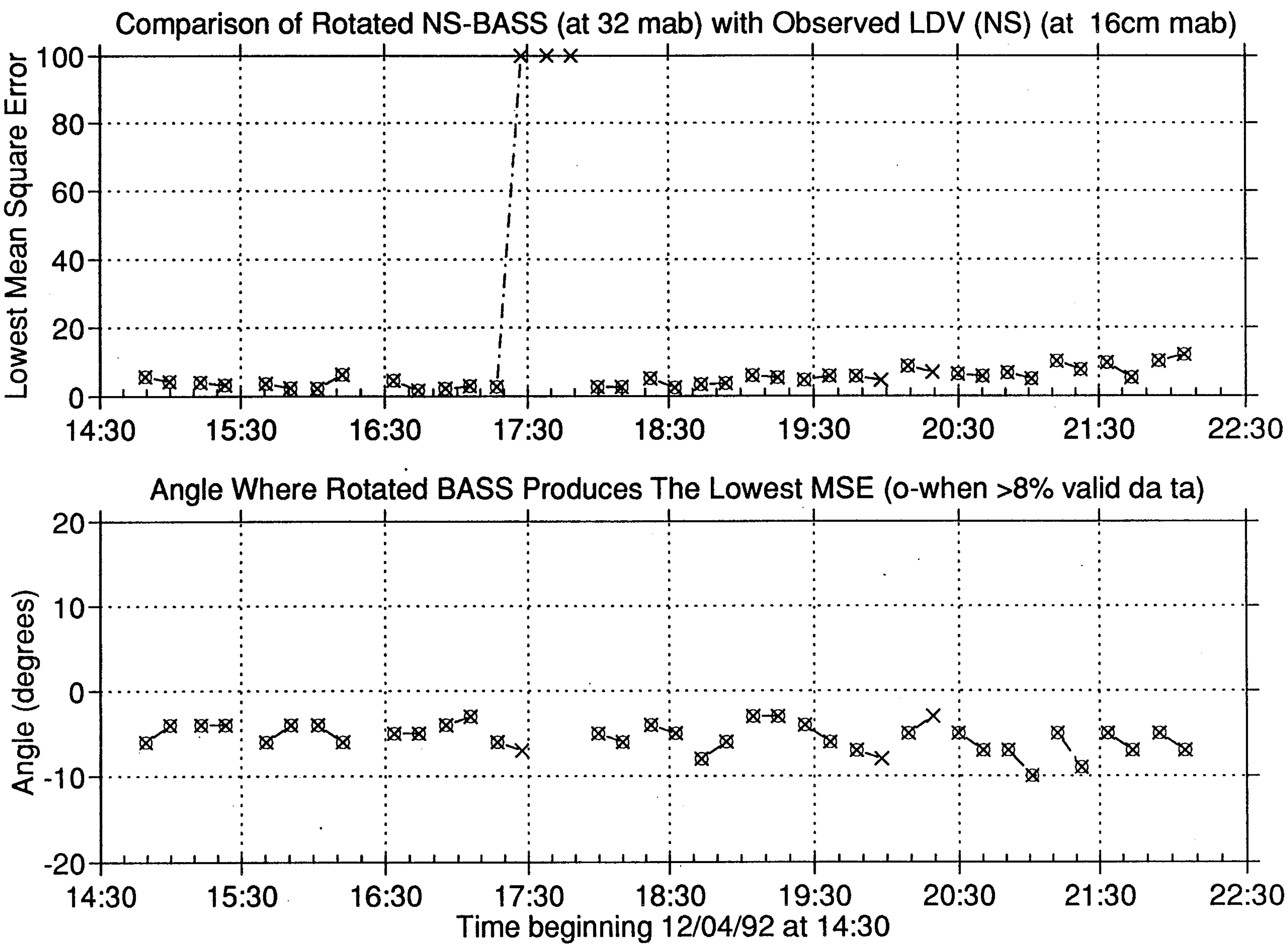
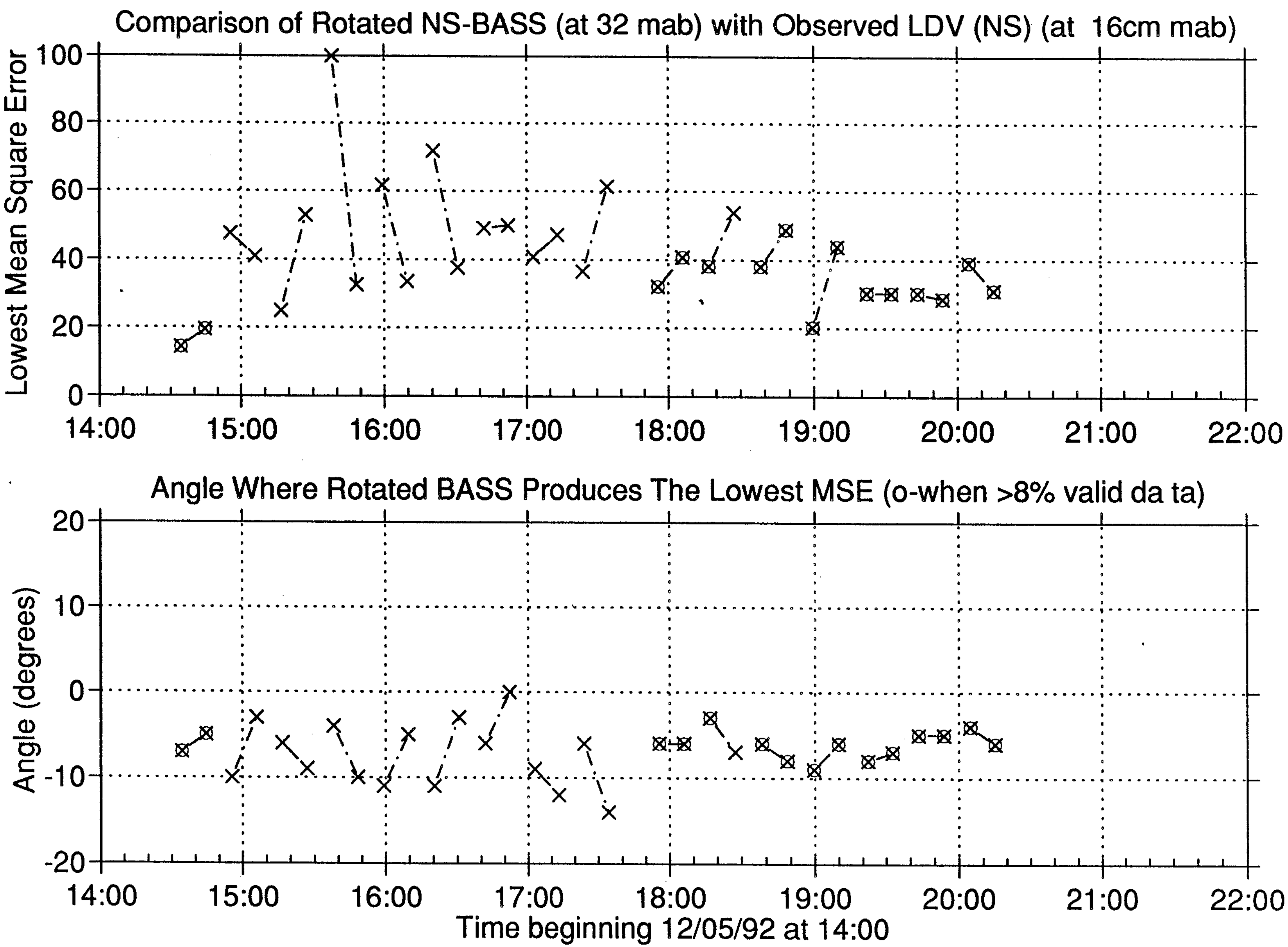
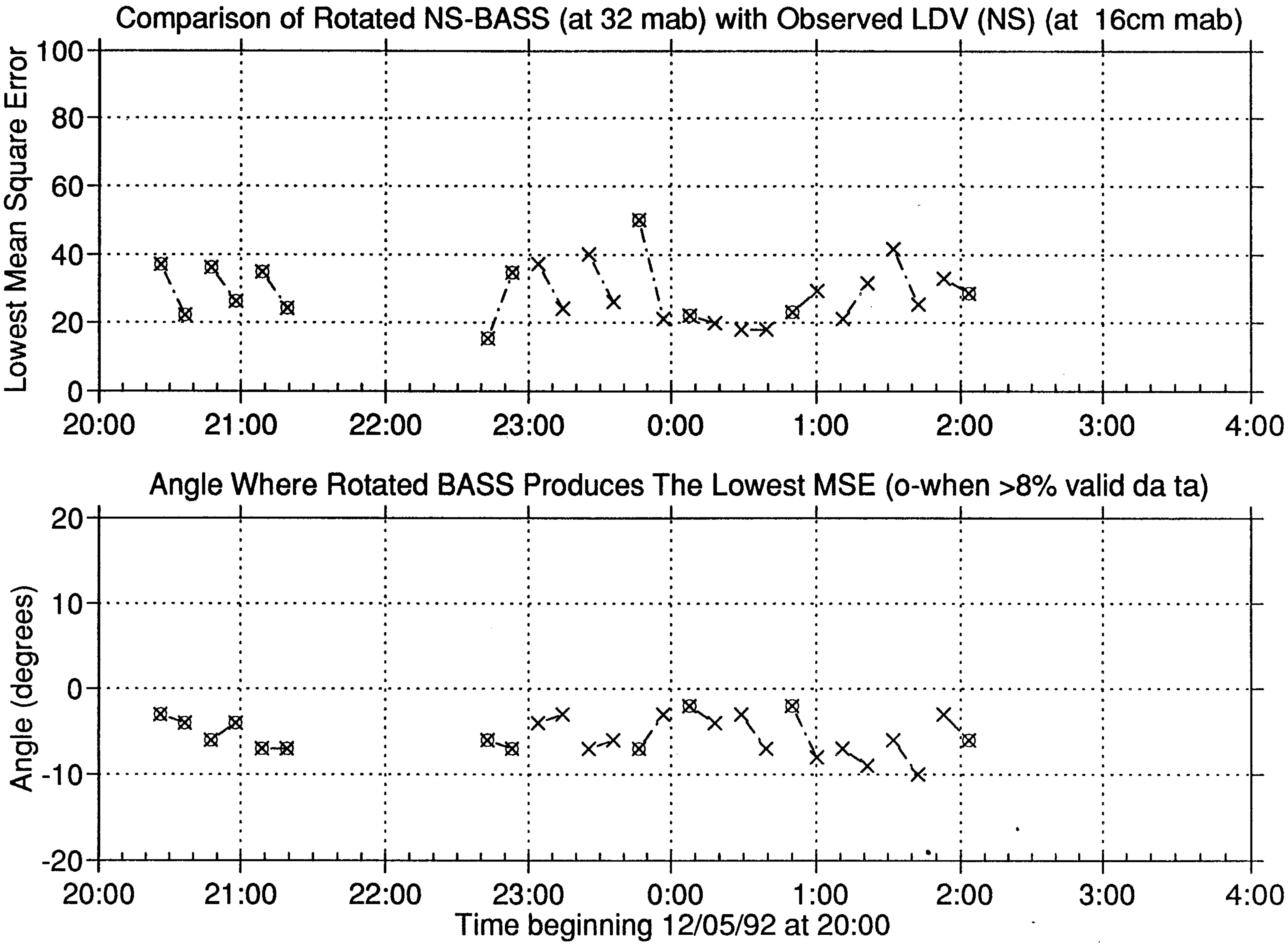

Comparison of Rotated NS-BASS (at 32 mab) with Observed LDV (NS) (at 16cm mab)
Lowest Mean Square Error
100
80
60
40
20
0
14:30
15:30
16:30
17:30
18:30
19:30
20:30
21:30
22:30
Angle Where Rotated BASS Produces The Lowest MSE (o-when >8% valid da ta)
Angle (degrees)
20
10
0
-10
-20
14:30
15:30
16:30
17:30
18:30
19:30
20:30
21:30
22:30
Time beginning 12/04/92 at 14:30

Figure 23.



Comparison of Rotated NS-BASS (at 32 mab) with Observed LDV (NS) (at 16cm mab)
Lowest Mean Square Error
100
80
60
40
20
0
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
Angle Where Rotated BASS Produces The Lowest MSE (o-when >8% valid da ta)
Angle (degrees)
20
10
0
-10
-20
Time beginning 12/05/92 at 14:00

Figure 24.



Comparison of Rotated NS-BASS (at 32 mab) with Observed LDV (NS) (at 16cm mab)
Lowest Mean Square Error
100
80
60
40
20
0
20:00
21:00
22:00
23:00
0:00
1:00
2:00
3:00
4:00
Angle Where Rotated BASS Produces The Lowest MSE (o-when >8% valid da ta)
Angle (degrees)
20
10
0
-10
-20
Time beginning 12/05/92 at 20:00

Figure 25.

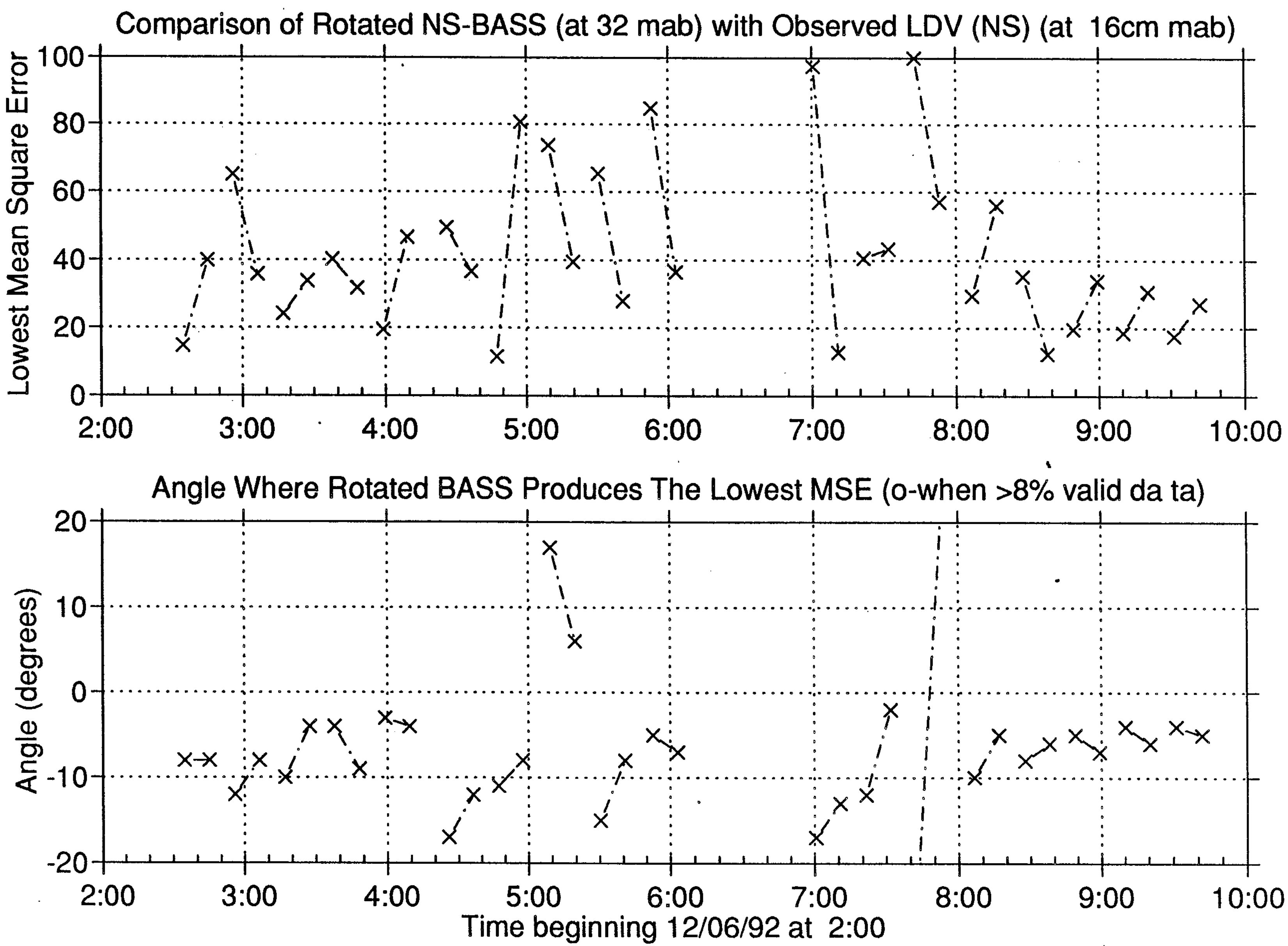

Comparison of Rotated NS-BASS (at 32 mab) with Observed LDV (NS) (at 16cm mab)
Lowest Mean Square Error
100
80
60
40
20
0
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
Angle Where Rotated BASS Produces The Lowest MSE (o-when >8% valid da ta)
Angle (degrees)
20
10
0
-10
-20
Time beginning 12/06/92 at 2:00

Figure 26.

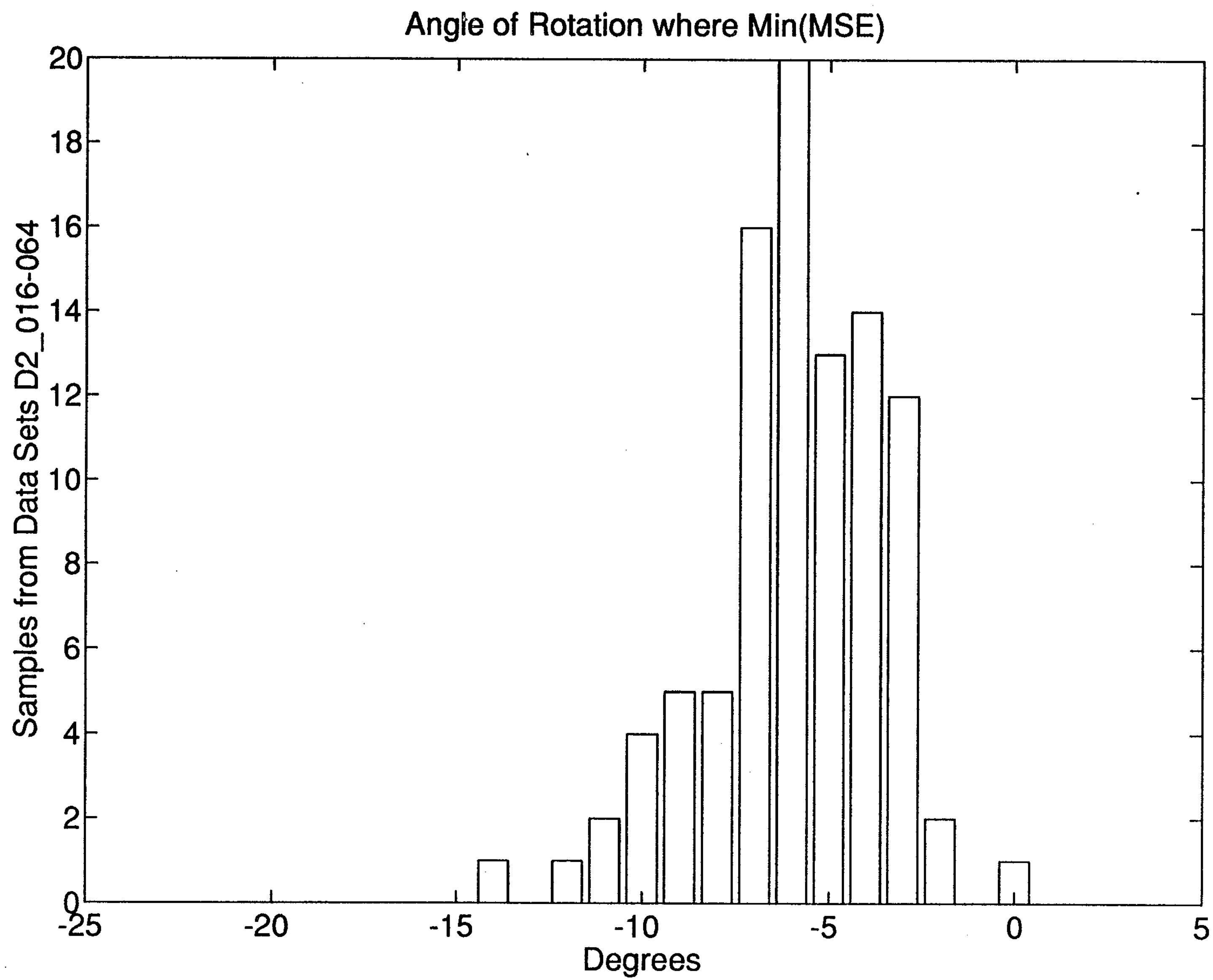

Angle of Rotation where Min(MSE)
Samples from Data Sets D2_016-064
Degrees
20
18
16
14
12
10
8
6
4
2
0
-25
-20
-15
-10
-5
0
5

Figure 27.

5.2.2 Gain Factors and Correlation Coefficients

As seen in Figures 28-31, good correlation exists between the NS-LDV and the NS-BASS. A first order fit of the data, after rotating the BASS and removing the means, indicates that appropriate gain factors were applied in the conversions from counts to cm/s.

Since the EW-LDV data were processed as described in Section 4, we would expect the high correlation as seen in Figure 32. The gain factor used in processing the EW-LDV was derived by the comparison to the rotated EW-BASS (after removal of the mean).

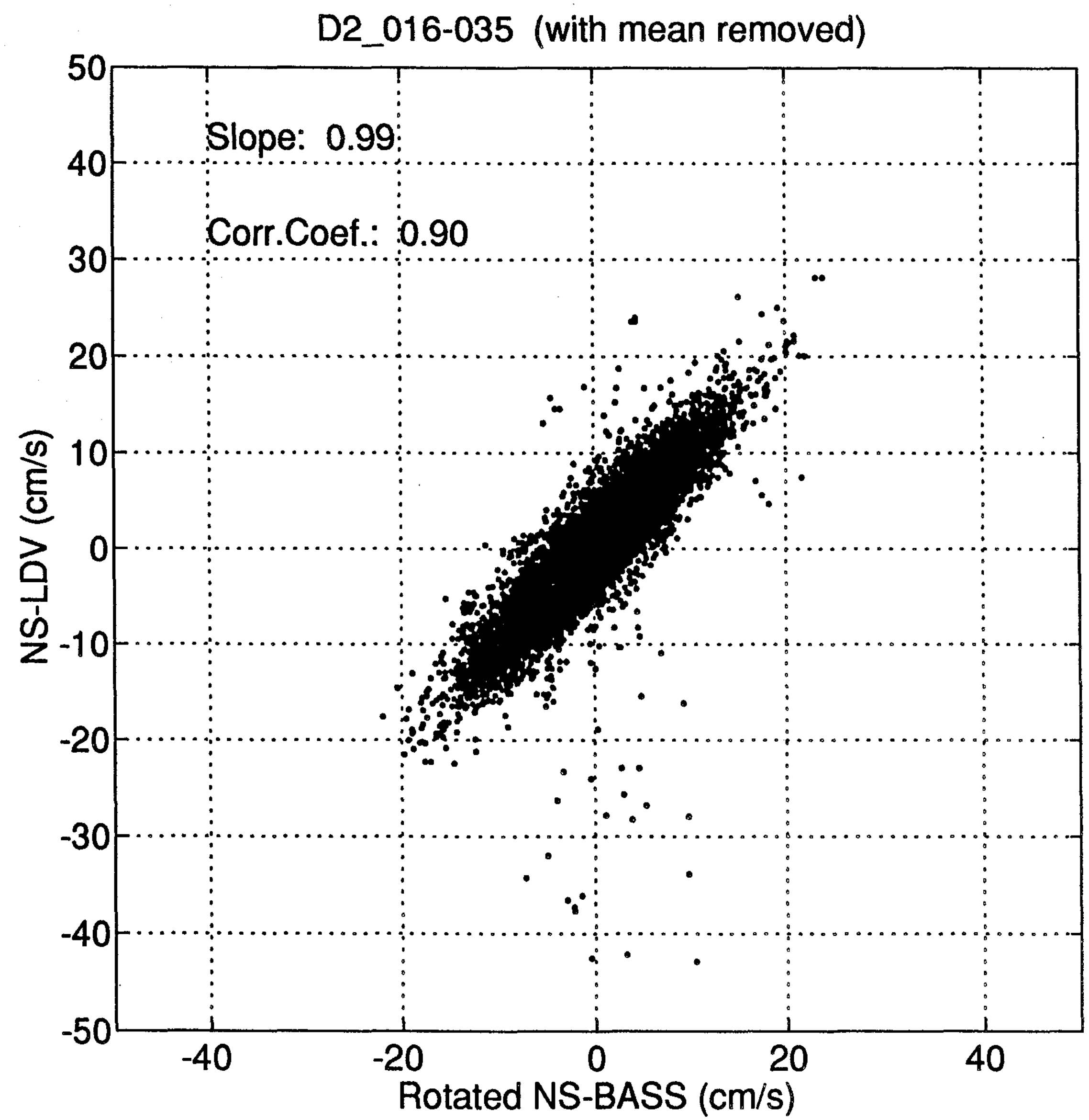

D2_016-035 (with mean removed)
Slope: 0.99
Corr.Coef.: 0.90
NS-LDV (cm/s)
Rotated NS-BASS (cm/s)
50
40
30
20
10
0
-10
-20
-30
-40
-50
-40
-20
0
20
40

Figure 28.

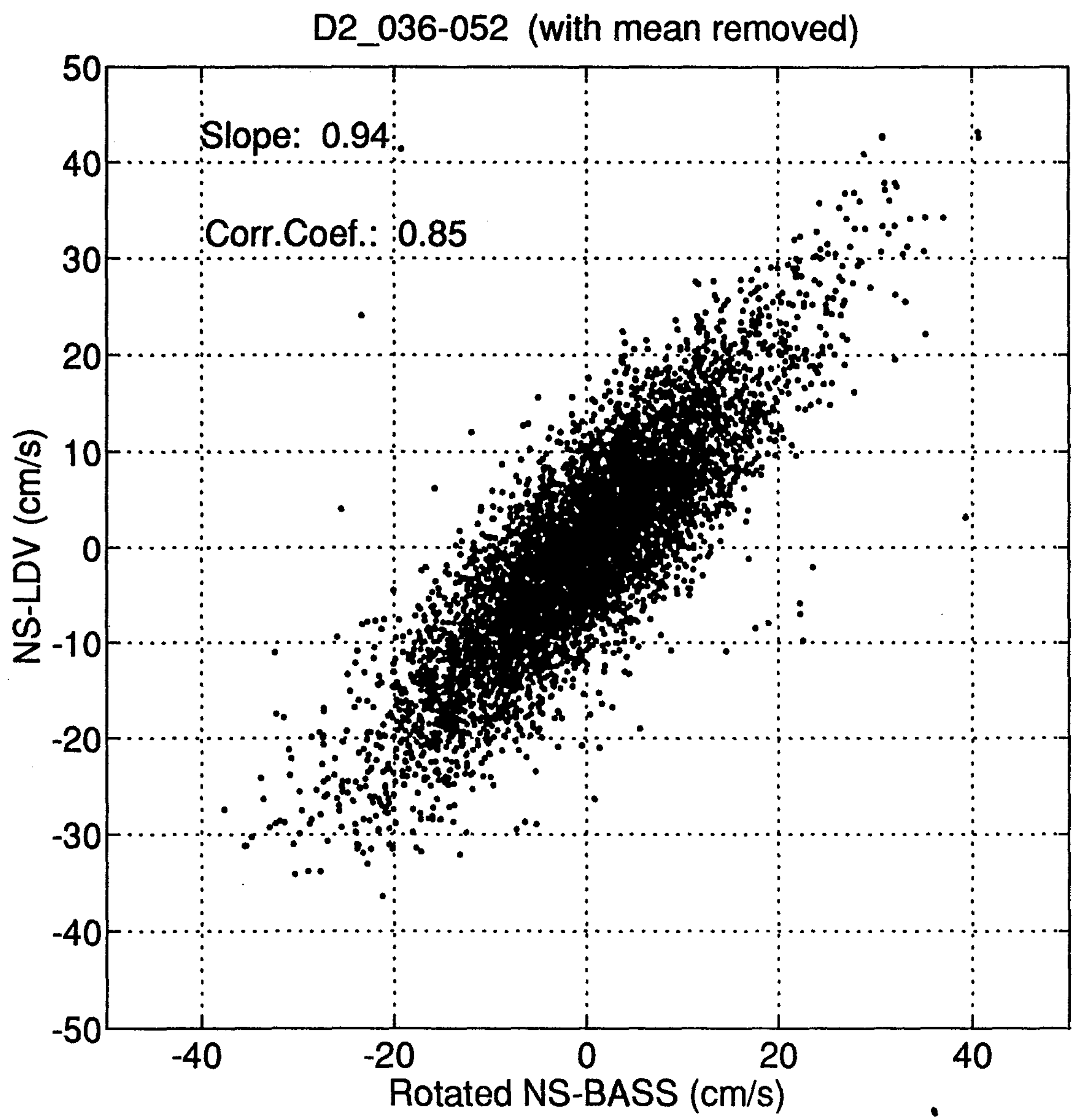

D2_036-052 (with mean removed)
Slope: 0.94
Corr.Coef.: 0.85
NS-LDV (cm/s)
Rotated NS-BASS (cm/s)
50
40
30
20
10
0
-10
-20
-30
-40
-50
-40
-20
0
20
40

Figure 29.

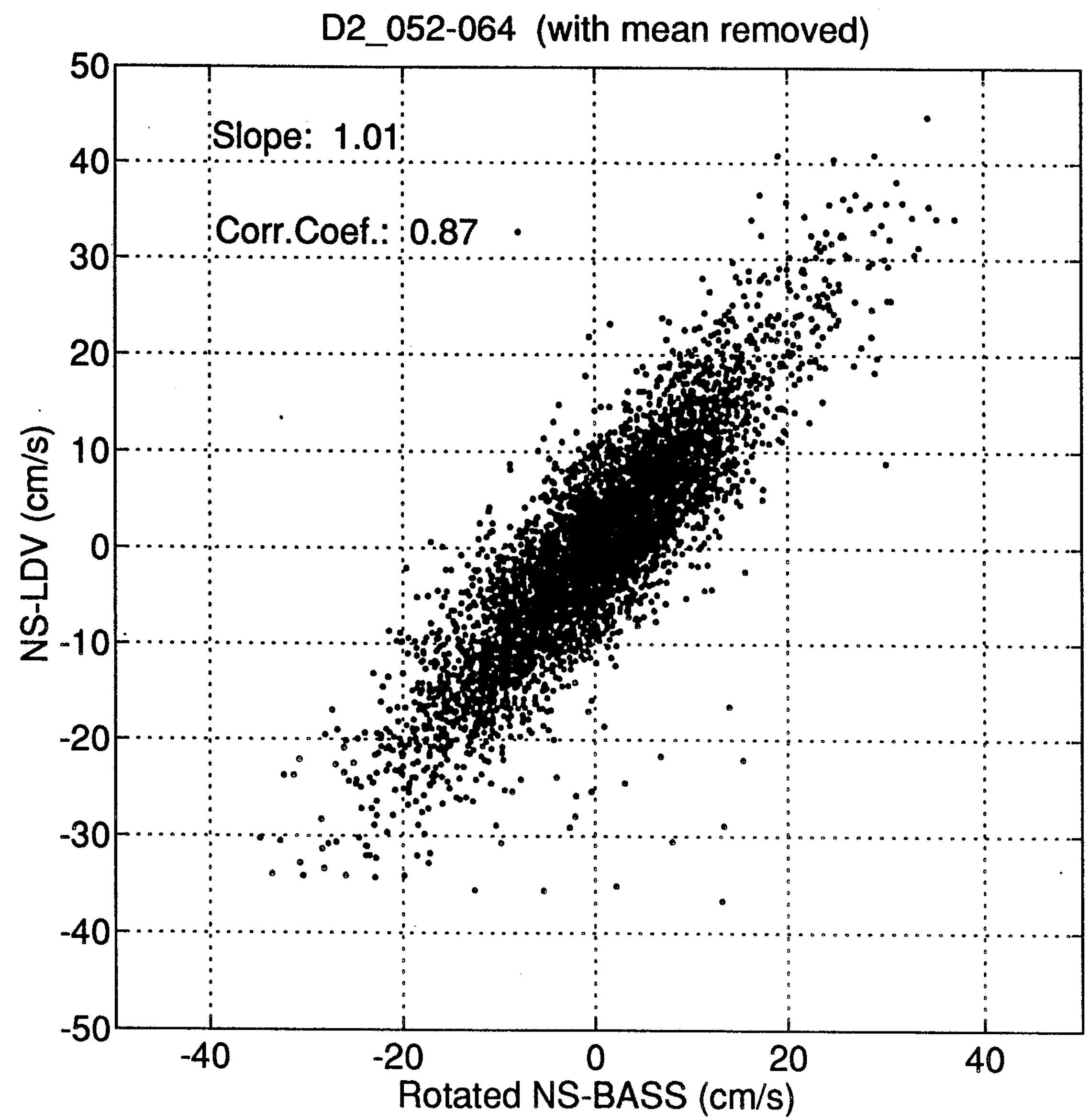

D2_052-064 (with mean removed)
Slope: 1.01
Corr.Coef.: 0.87
NS-LDV (cm/s)
Rotated NS-BASS (cm/s)
50
40
30
20
10
0
-10
-20
-30
-40
-50
-40
-20
0
20
40

Figure 30.

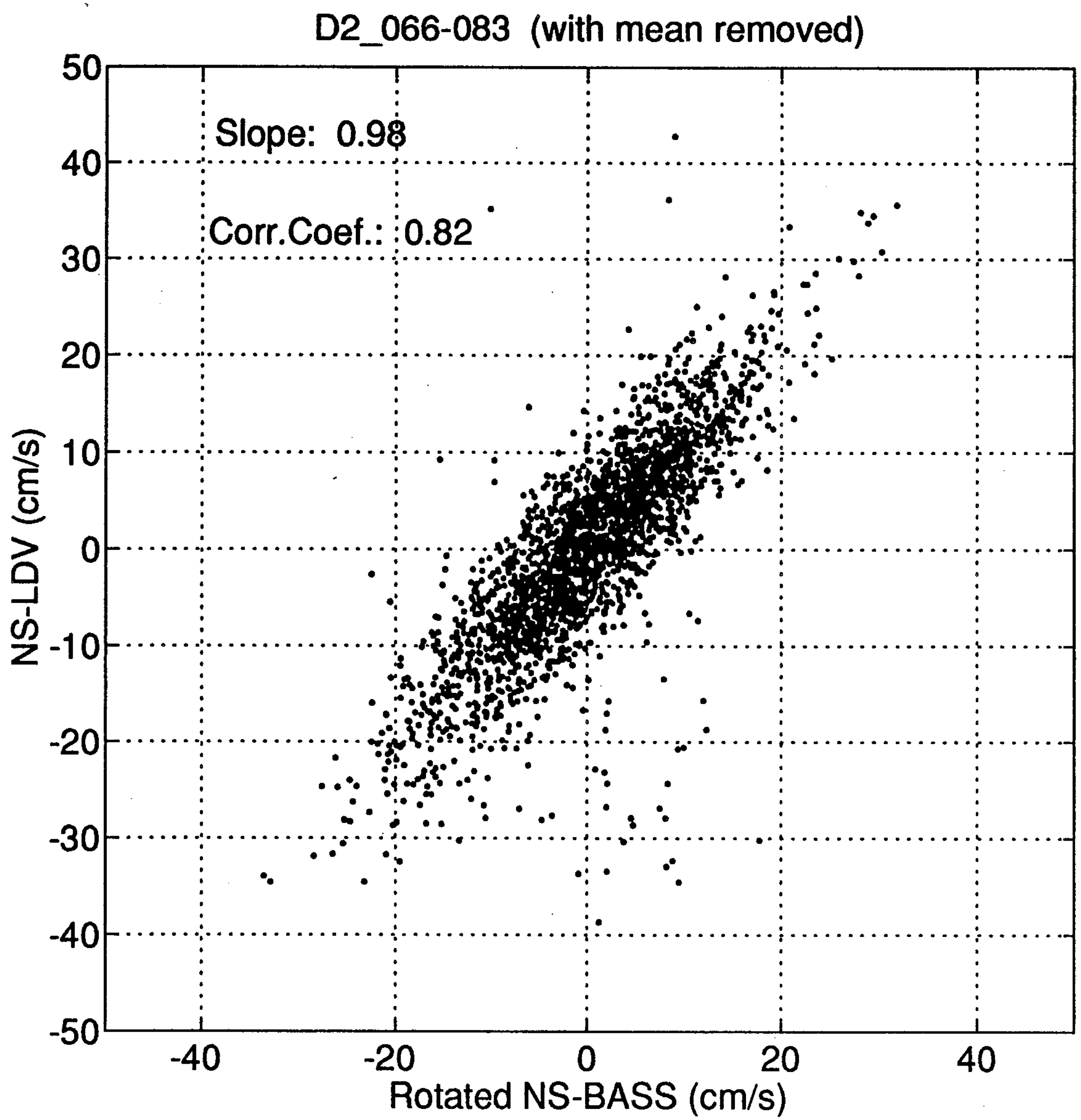

D2_066-083 (with mean removed)
Slope: 0.98
Corr.Coef.: 0.82
NS-LDV (cm/s)
Rotated NS-BASS (cm/s)
50
40
30
20
10
0
-10
-20
-30
-40
-50
-40
-20
0
20
40

Figure 31.

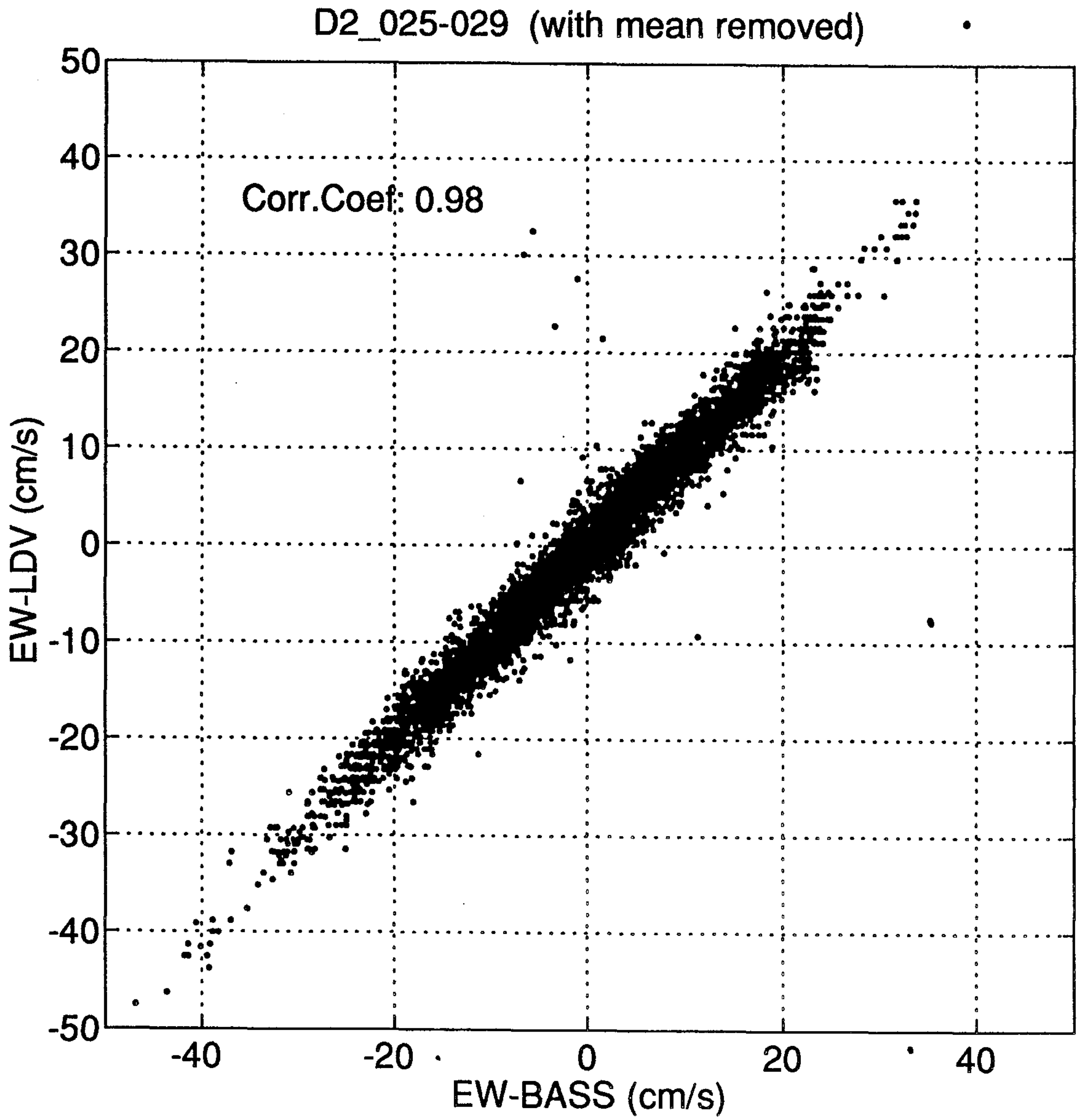
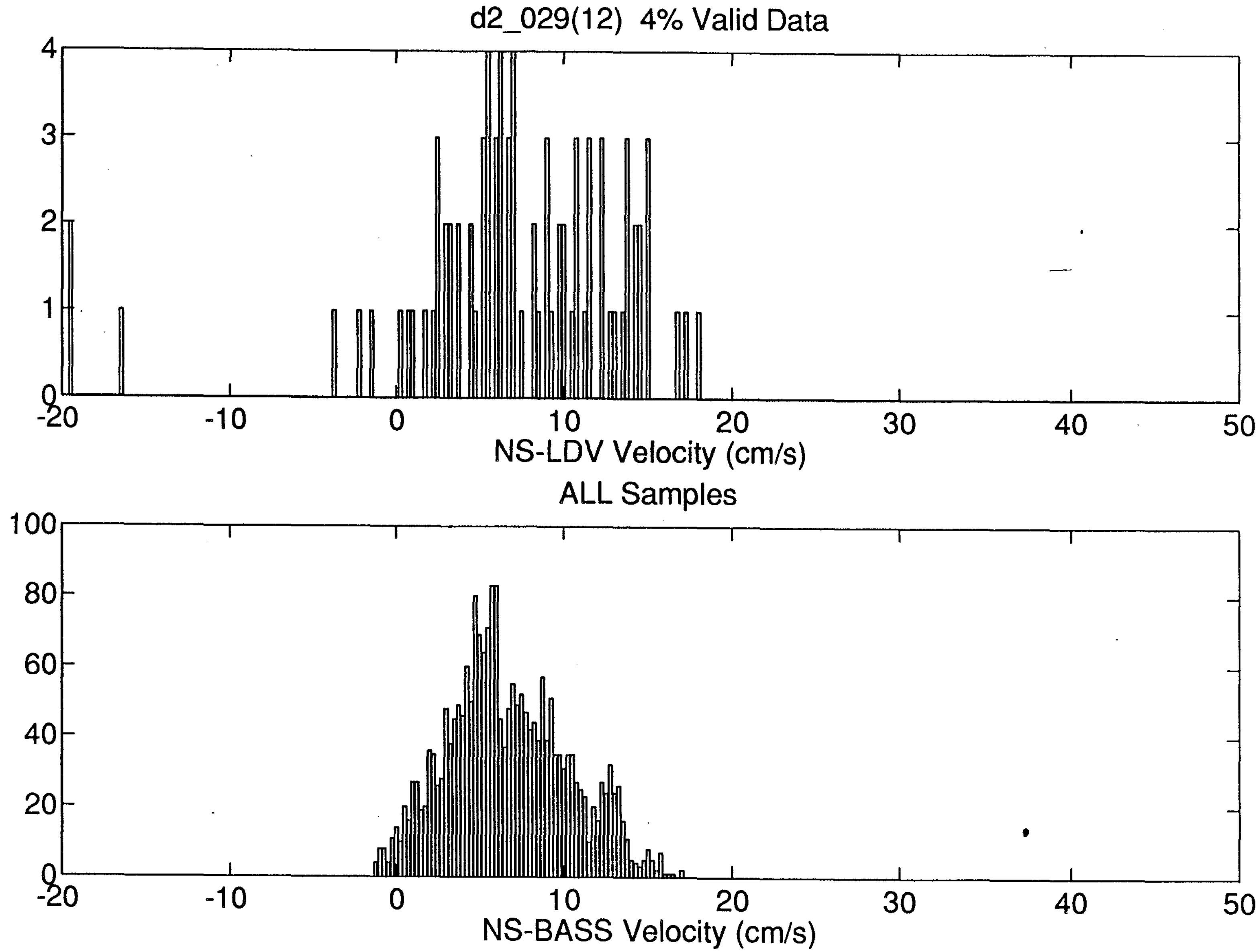

D2_025-029 (with mean removed)
Corr.Coef: 0.98
EW-LDV (cm/s)
EW-BASS (cm/s)
50
40
30
20
10
0
-10
-20
-30
-40
-50
-40
-20
0
20
40

Figure 32.

5.2.3 LDV Data Return Rate

As described in Section 4, a quality word indicated when a good signal was recorded for each LDV axis. The return rate was often low and is illustrated by three time series of NS-LDV included as Figures 33-38. For comparison, the concurrent NS-BASS time series are also included. An overview of the percentage of NS-LDV which was returned as valid for each 88-second record is included as Figures 39-43. Along with this percentage, we have included the mean square error (MSE), as described above, of the NS-LDV from the NS-BASS at the top-most LDV sampling elevation. The top-most elevations (eid 6 and 12) are circled in the percentage plots to provide visual comparison of the MSE and the percentage at the corresponding elevations. As summarized in Figure 44, the mean square error appears to be a function of the return rate and Figure 45 indicates that the return rate is a function of the mean of the velocity squared. The coincidence of high MSE with increased velocity is verified in Figure 46, which also indicates problems at very low velocities. This may be a result of the limited or saturated sediment concentrations during times of slow or high velocities, respectively. To test the effect of the low LDV data return rate on velocity statistics, we subsampled the NS-BASS using the indices of the valid NS-LDV. In Figures 47-50, note the difference between the statistical analyses of the BASS (all samples - 'o') and the subsampled BASS (subsampled with the indices of the valid LDV - 'x'). It can be seen that the BASS, subsampled as the LDV valid data, produces a biased mean and therefore we cannot assume uniform sumsampling has occurred. The histograms shown in Figures 51-54 represent approximately an hour of observation and have not had the means removed. These plots suggest that the LDV was undersampling more often during strong southerly flow.

To increase the data return rate of the NS-LDV, we attempted to restore data within a given tolerance of the valid signal. A quadratic fit was determined through small sections of the valid data and points falling within a given tolerance of the fit were added back into the undersampled profile (see **maxpoint.m** in Appendix B). Figures 55 and 56 show the resultant signal when the procedure was applied to two random records. The procedure increases the percentage return and, as seen in Figures 57-58 ('o' and 'x'), provides better representation of the profile. But, these figures also show that the procedure produced a biased mean of the NS-LDV as sampled with the maxpoint indices ('+'). In Figures 55-56, notice that noise does not occur uniformly. A dense line of points often occurred at about -10 cm/s (in both the northerly flow observations and southerly flow observations) and an increase in noise is apparent as the -48 cm/s cutoff is approached. Since the data are usually above this area during the milder, northerly flow, the mean is only slightly affected. But, when using maxpoint during the southerly flow, the mean becomes weighted as more of the noise from the populated areas are added back into the curve. For the purposes of this report, only those samples which have been flagged valid in the data qualifier field are presented. The maxpoint procedure is described here for future reference.



d2_029(12) 4% Valid Data
4
3
2
1
0
-20
-10
0
10
20
30
40
50
NS-LDV Velocity (cm/s)
ALL Samples
100
80
60
40
20
0
-20
-10
0
10
20
30
40
50
NS-BASS Velocity (cm/s)

Figure 33.

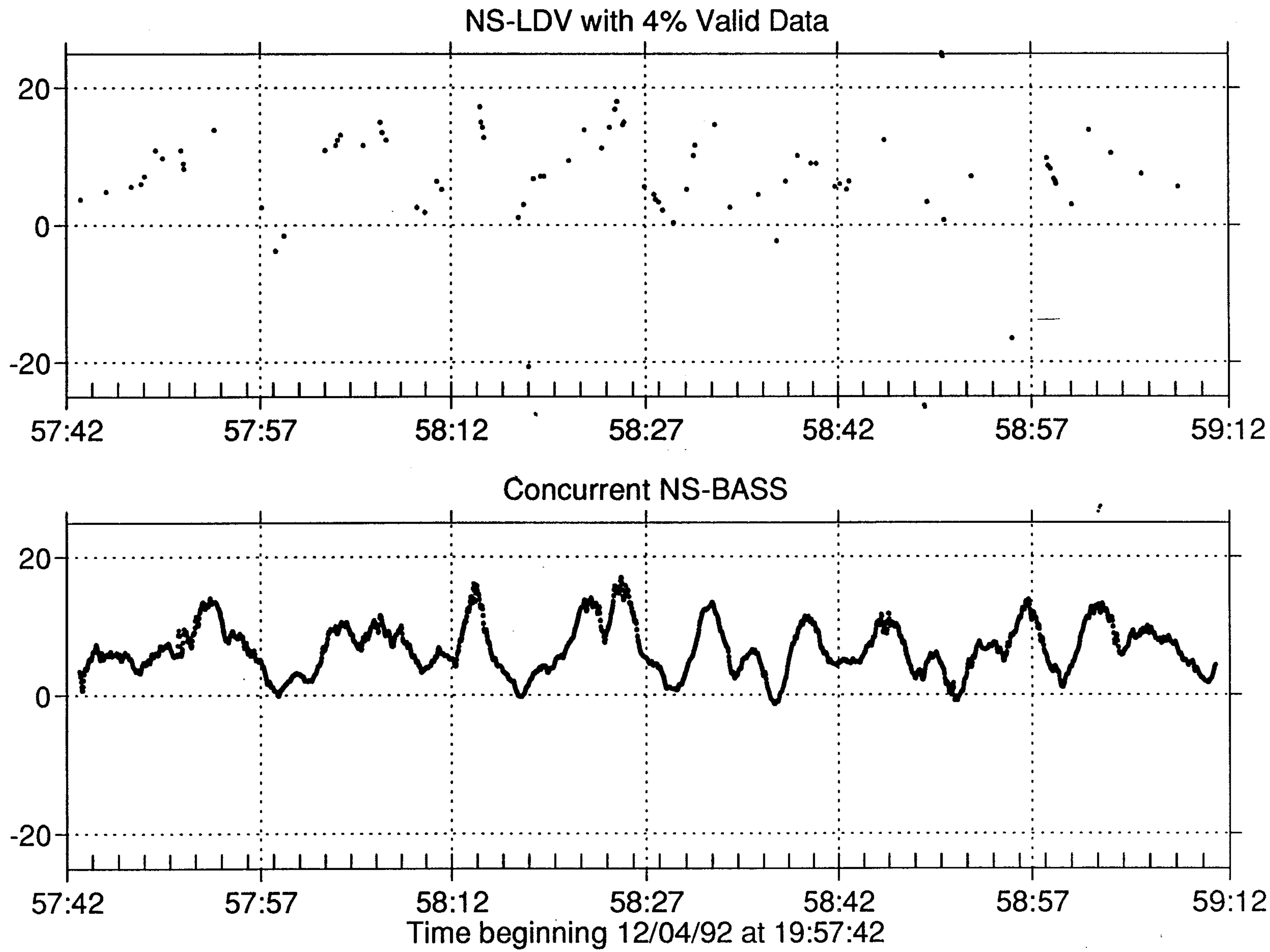

NS-LDV with 4% Valid Data
20
0
-20
57:42
57:57
58:12
58:27
58:42
58:57
59:12
Concurrent NS-BASS
20
0
-20
57:42
57:57
58:12
58:27
58:42
58:57
59:12
Time beginning 12/04/92 at 19:57:42

Figure 34.

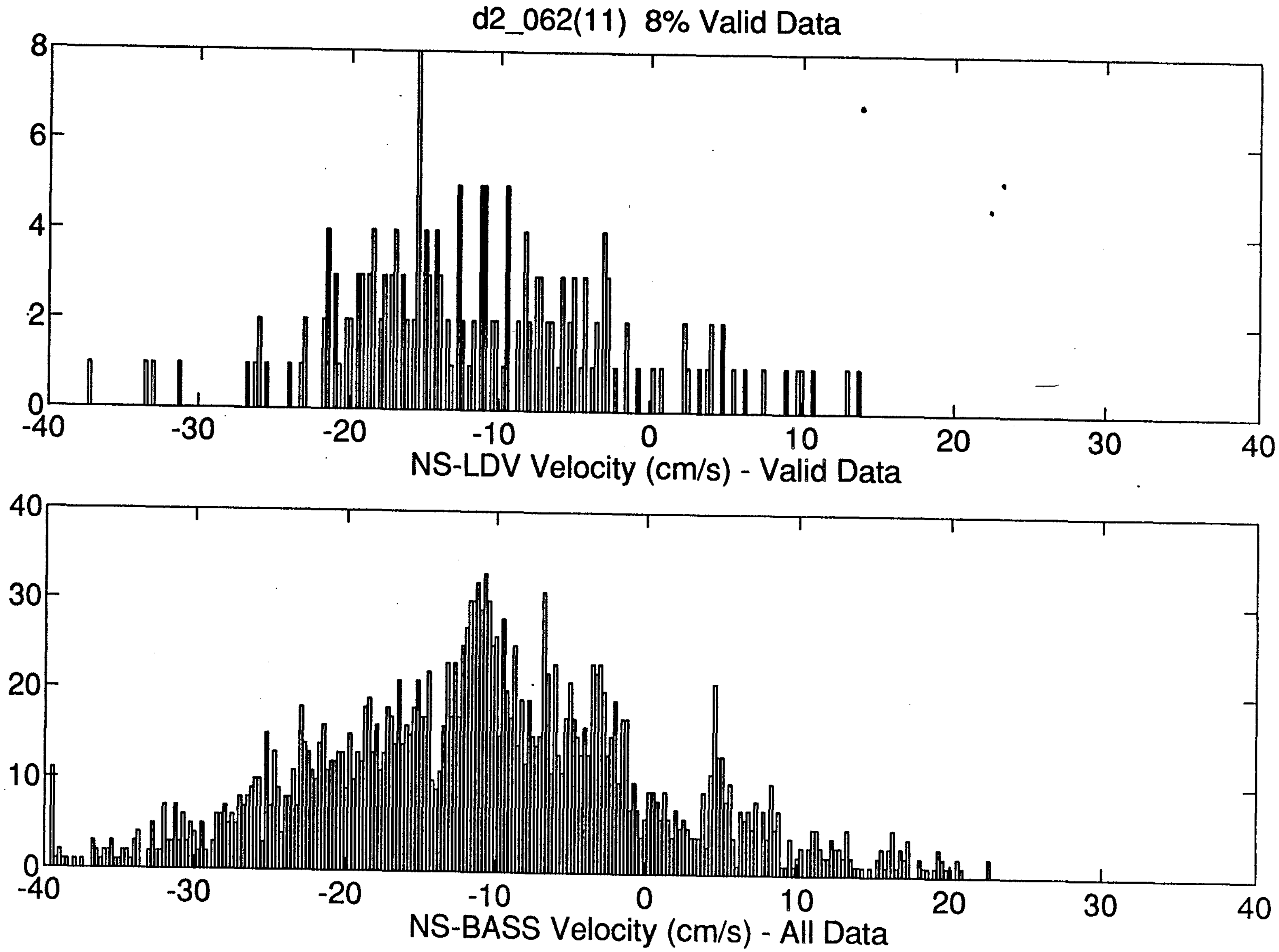

d2_062(11) 8% Valid Data
8
6
4
2
0
-40
-30
-20
-10
0
10
20
30
40
NS-LDV Velocity (cm/s) - Valid Data
40
30
20
10
0
-40
-30
-20
-10
0
10
20
30
40
NS-BASS Velocity (cm/s) - All Data

Figure 35.

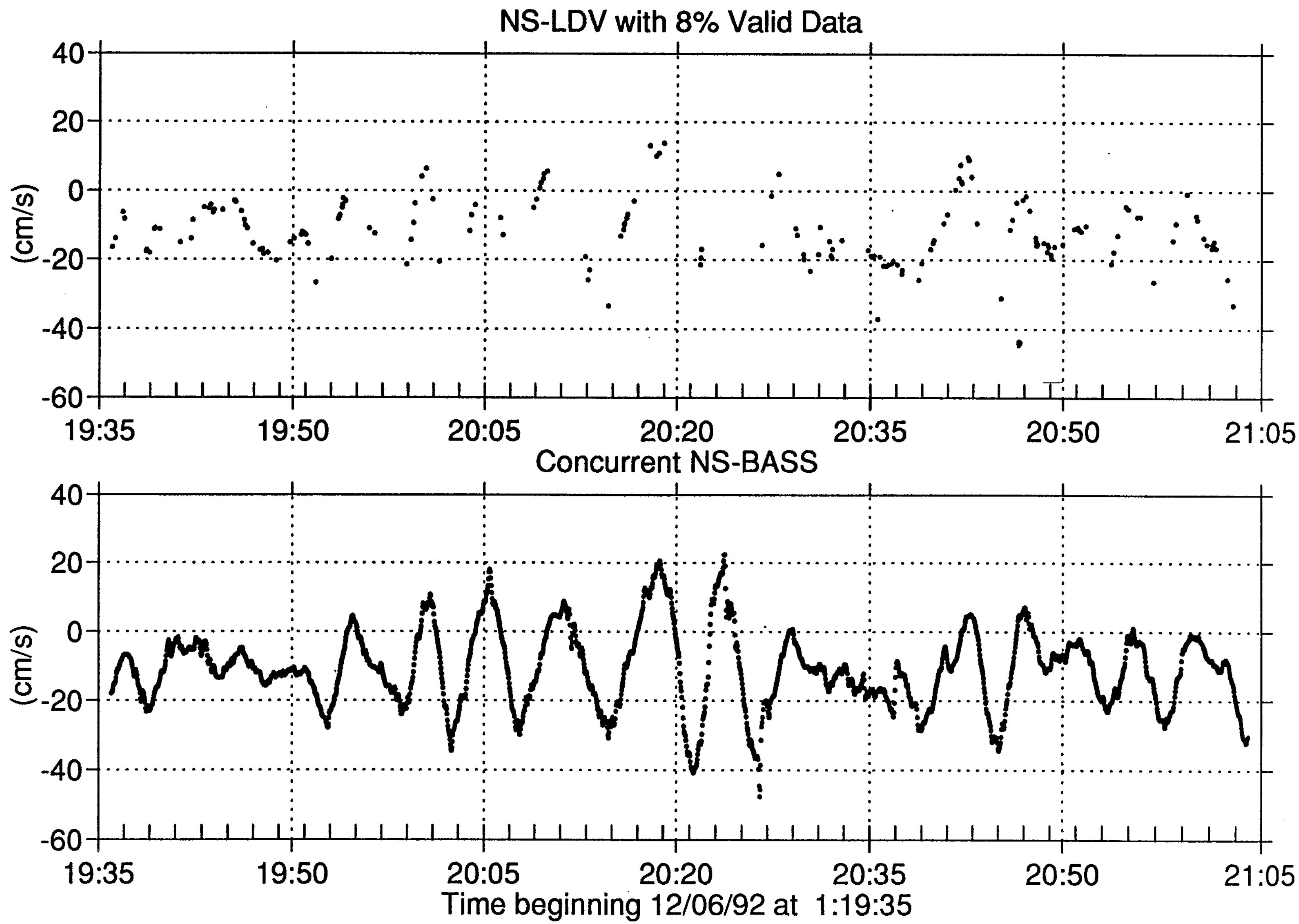
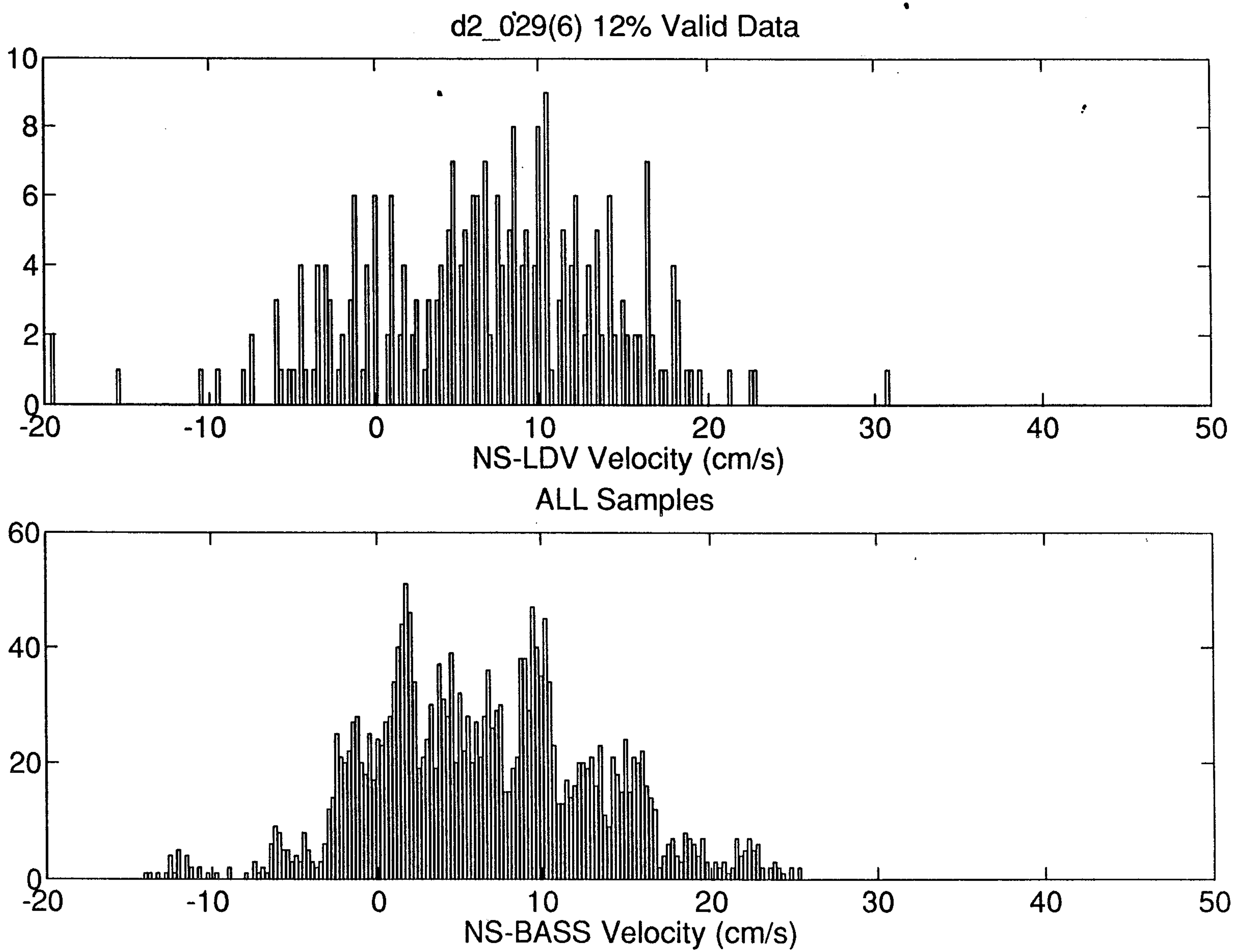

NS-LDV with 8% Valid Data
(cm/s)
40
20
0
-20
-40
-60
19:35
19:50
20:05
20:20
20:35
20:50
21:05
Concurrent NS-BASS
(cm/s)
40
20
0
-20
-40
-60
19:35
19:50
20:05
20:20
20:35
20:50
21:05
Time beginning 12/06/92 at 1:19:35

Figure 36.



d2_029(6) 12% Valid Data
10
8
6
4
2
0
-20
-10
0
10
20
30
40
50
NS-LDV Velocity (cm/s)
ALL Samples
60
40
20
0
-20
-10
0
10
20
30
40
50
NS-BASS Velocity (cm/s)

Figure 37.

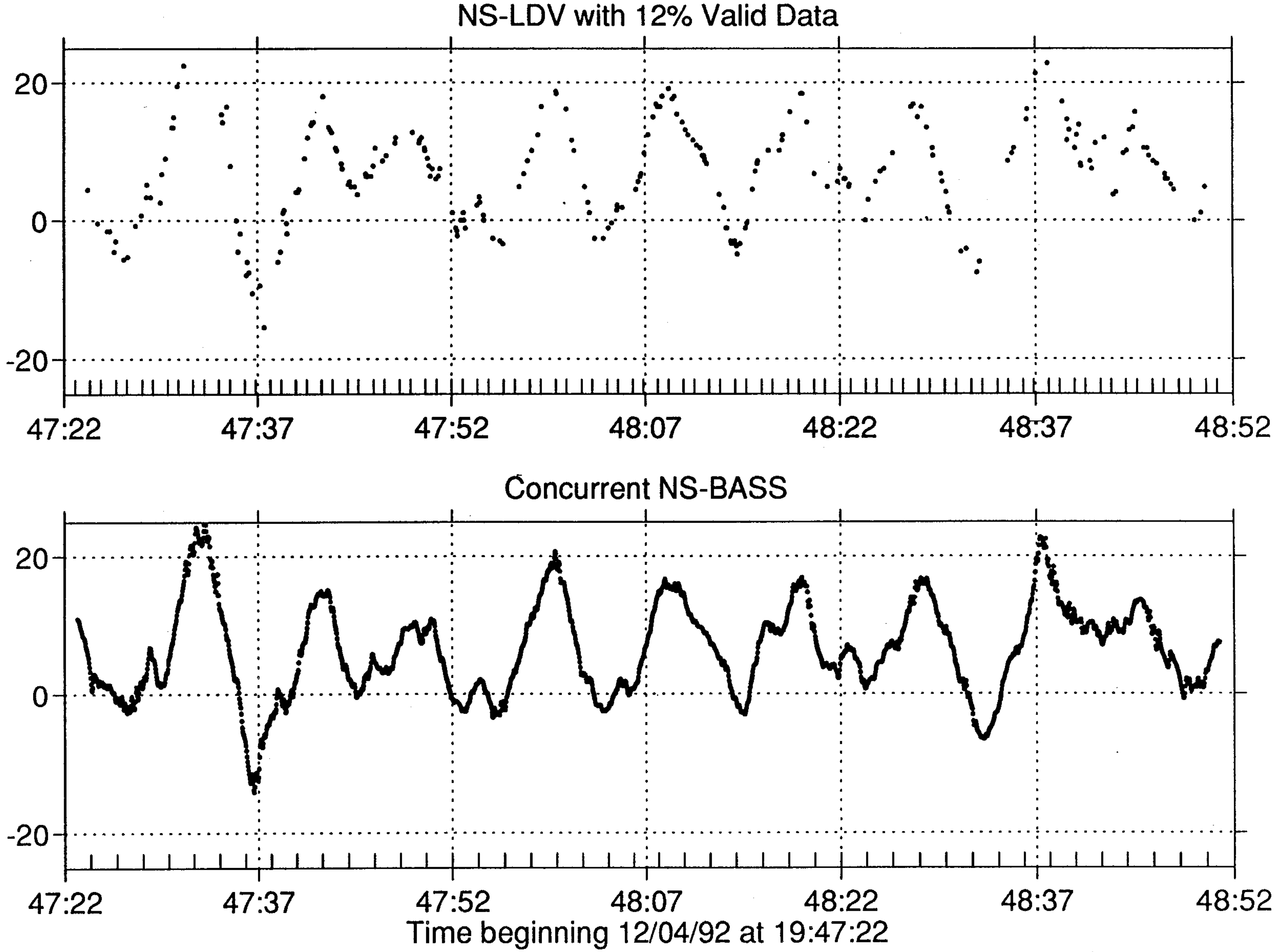

NS-LDV with 12% Valid Data
20
0
-20
47:22
47:37
47:52
48:07
48:22
48:37
48:52
Concurrent NS-BASS
20
0
-20
47:22
47:37
47:52
48:07
48:22
48:37
48:52
Time beginning 12/04/92 at 19:47:22

Figure 38.

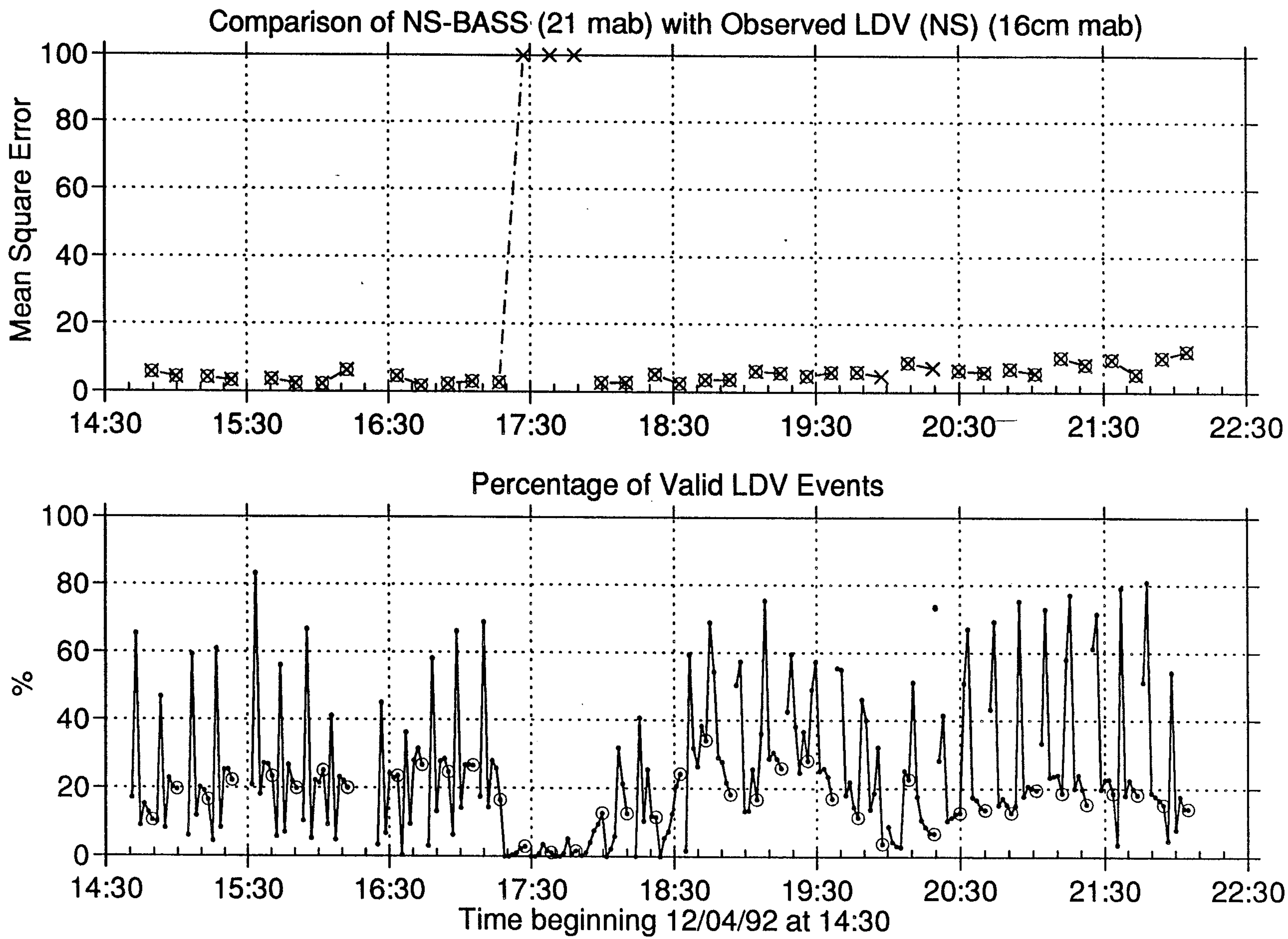

Comparison of NS-BASS (21 mab) with Observed LDV (NS) (16cm mab)
Mean Square Error
100
80
60
40
20
0
14:30
15:30
16:30
17:30
18:30
19:30
20:30
21:30
22:30
Percentage of Valid LDV Events
%
100
80
60
40
20
0
14:30
15:30
16:30
17:30
18:30
19:30
20:30
21:30
22:30
Time beginning 12/04/92 at 14:30

Figure 39.

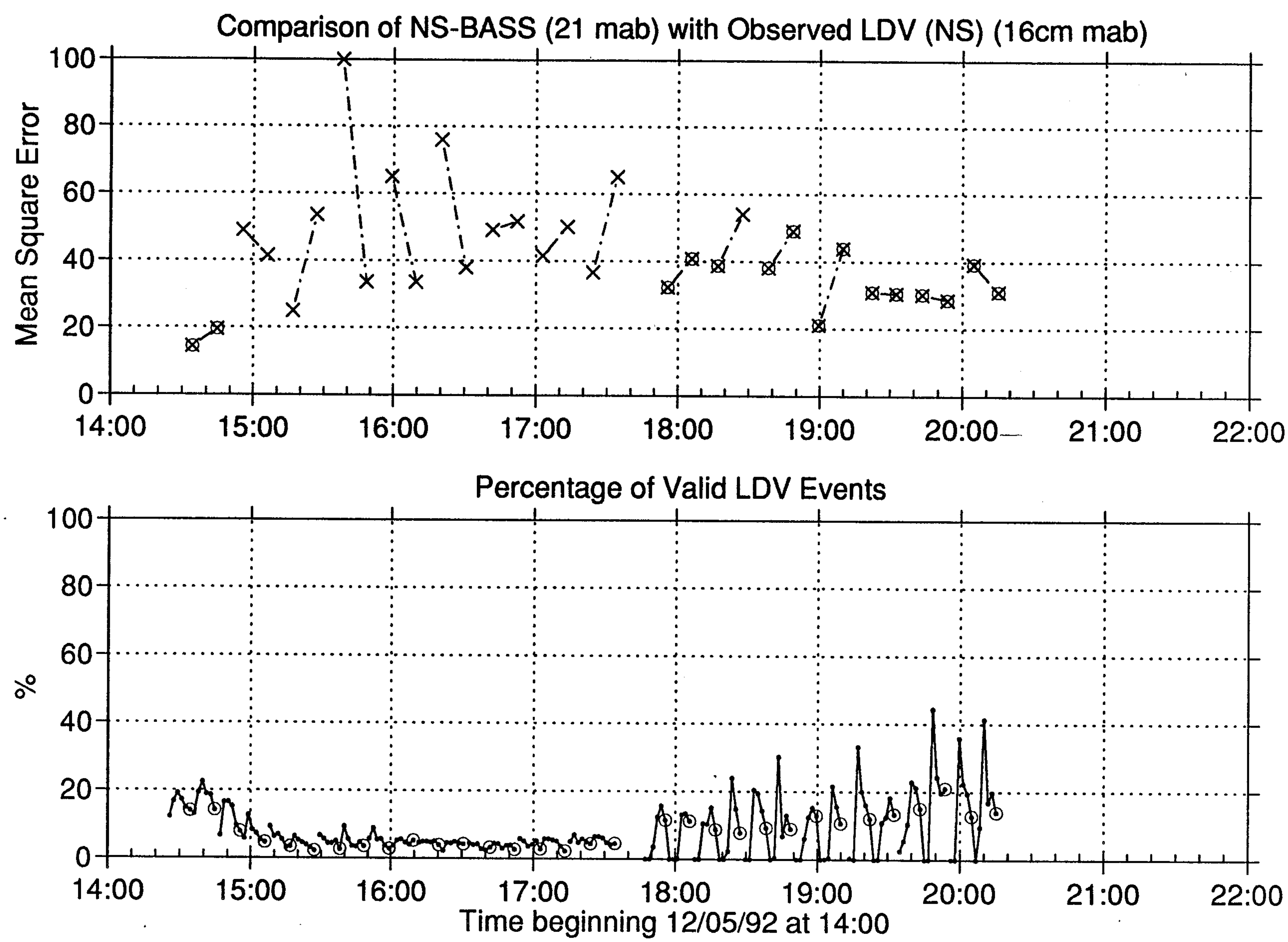

Comparison of NS-BASS (21 mab) with Observed LDV (NS) (16cm mab)
Mean Square Error
100
80
60
40
20
0
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
Percentage of Valid LDV Events
%
Time beginning 12/05/92 at 14:00

Figure 40.

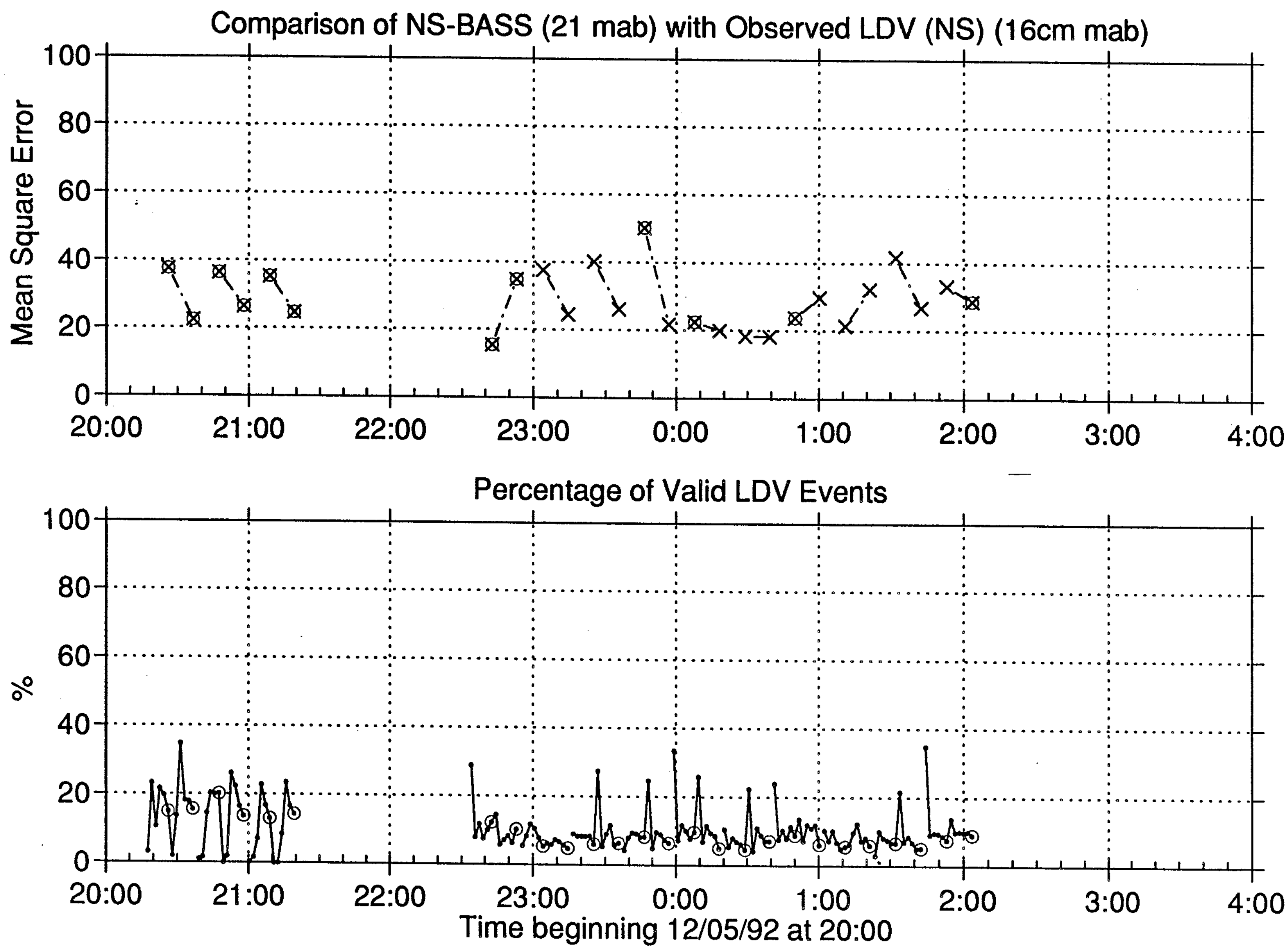
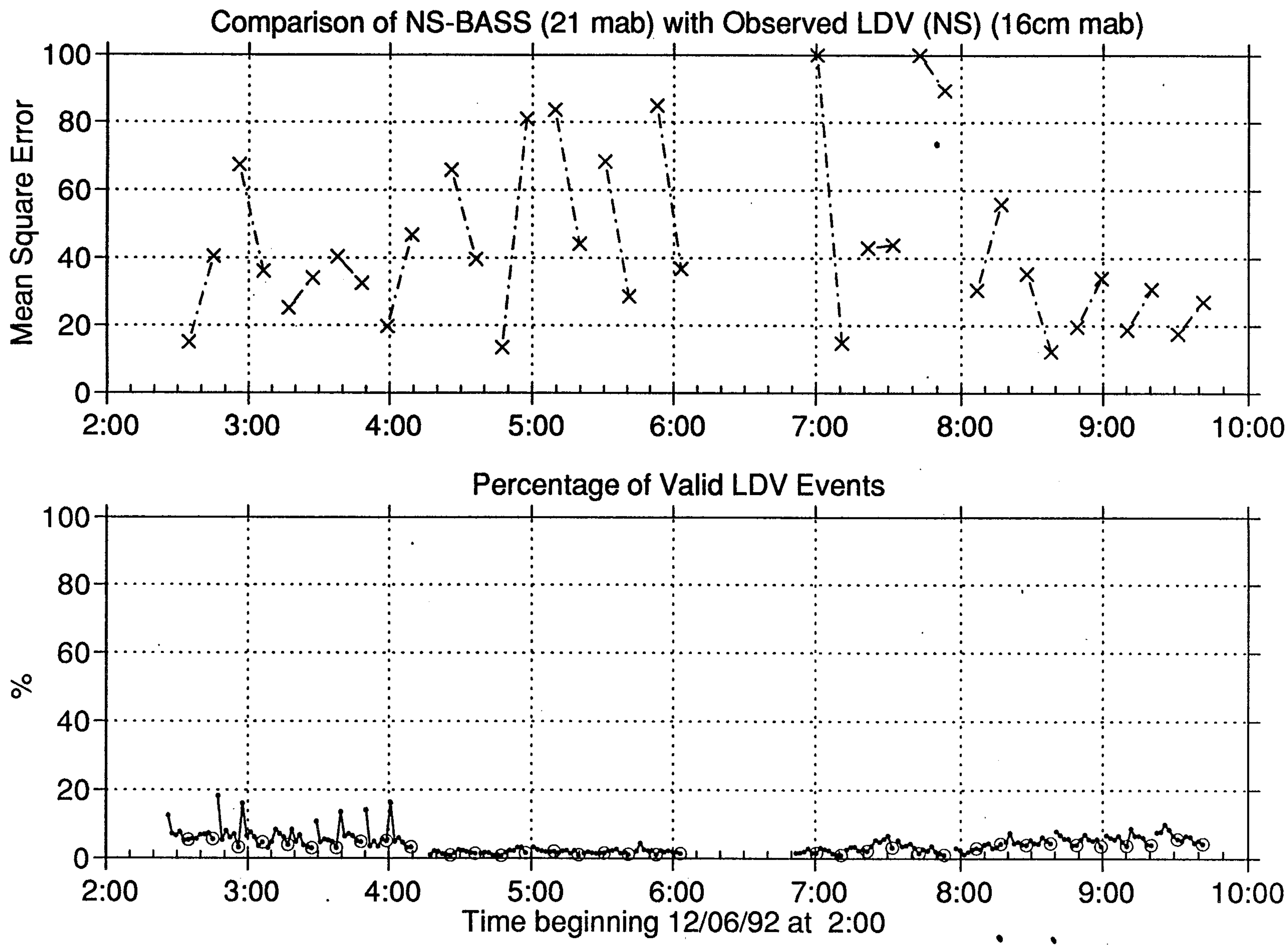

Comparison of NS-BASS (21 mab) with Observed LDV (NS) (16cm mab)
Mean Square Error
100
80
60
40
20
0
20:00
21:00
22:00
23:00
0:00
1:00
2:00
3:00
4:00
Percentage of Valid LDV Events
%
Time beginning 12/05/92 at 20:00

Figure 41.



Comparison of NS-BASS (21 mab) with Observed LDV (NS) (16cm mab)
Mean Square Error
100
80
60
40
20
0
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
Percentage of Valid LDV Events
%
100
80
60
40
20
0
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
Time beginning 12/06/92 at 2:00

Figure 42.

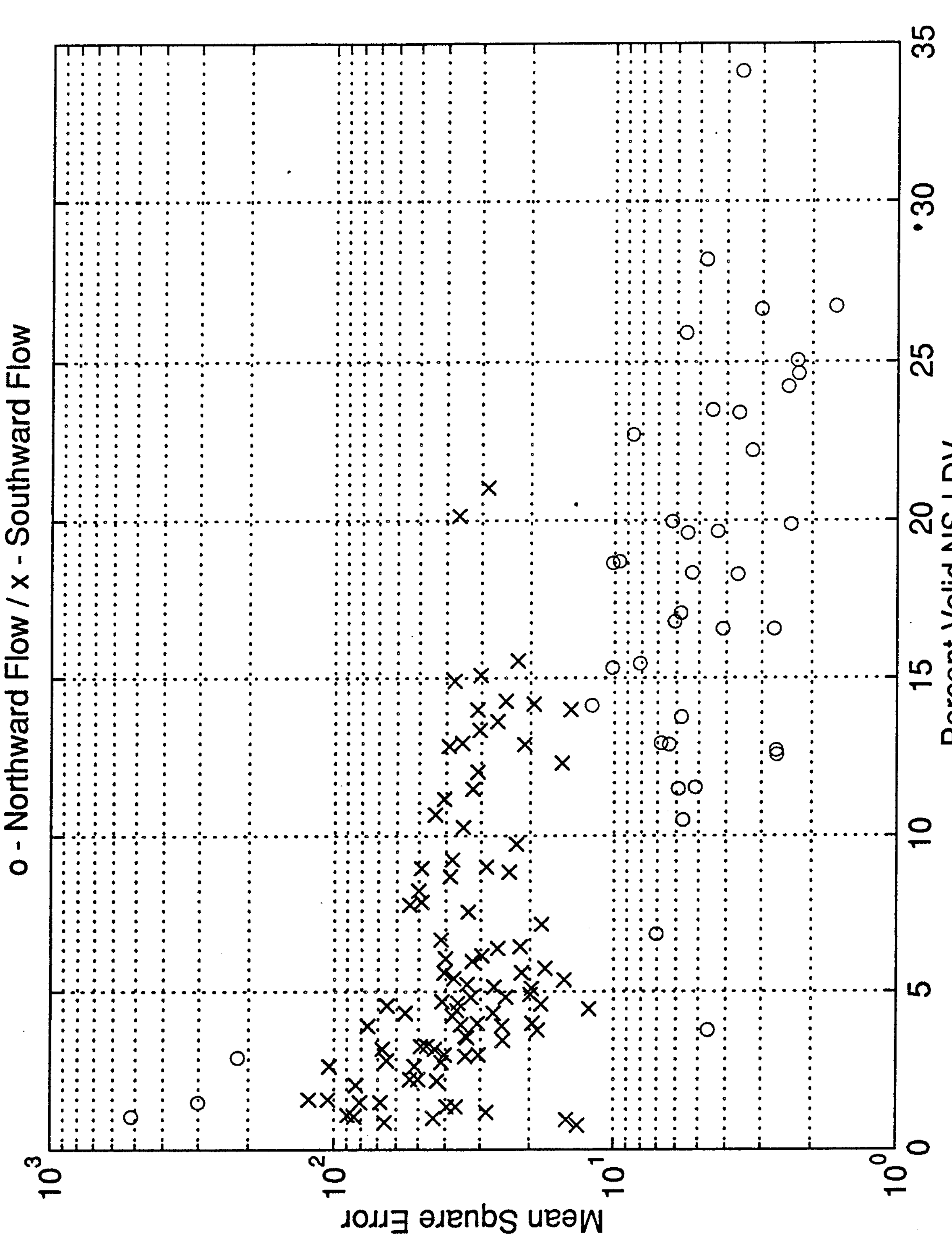

o - Northward Flow / x - Southward Flow
Mean Square Error
Percent Valid NS-LDV
10^3
10^2
10^1
10^0
0
5
10
15
20
25
30
35

Figure 43.

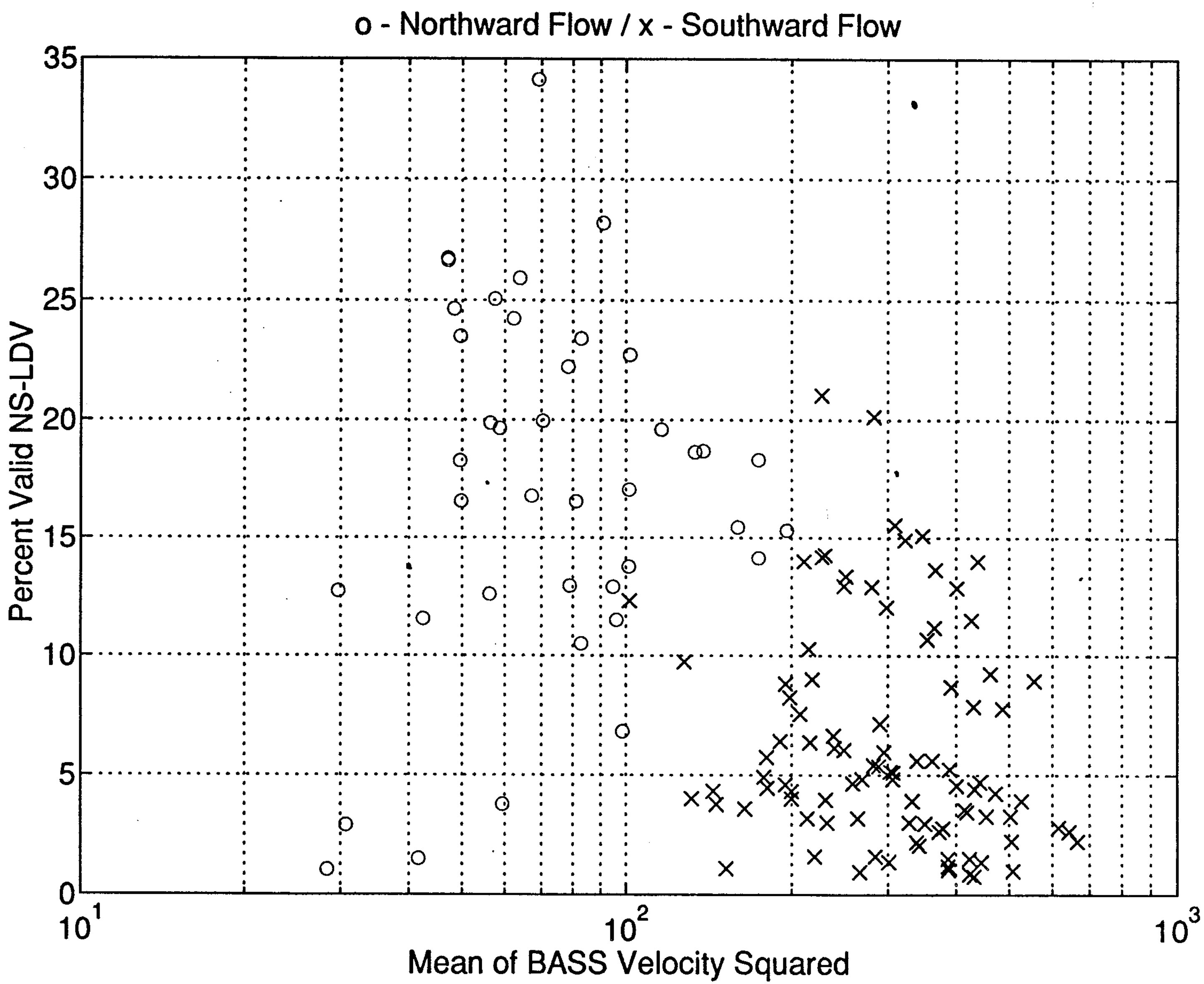

o - Northward Flow / x - Southward Flow
Percent Valid NS-LDV
35
30
25
20
15
10
5
0
10^1
10^2
10^3
Mean of BASS Velocity Squared

Figure 44.

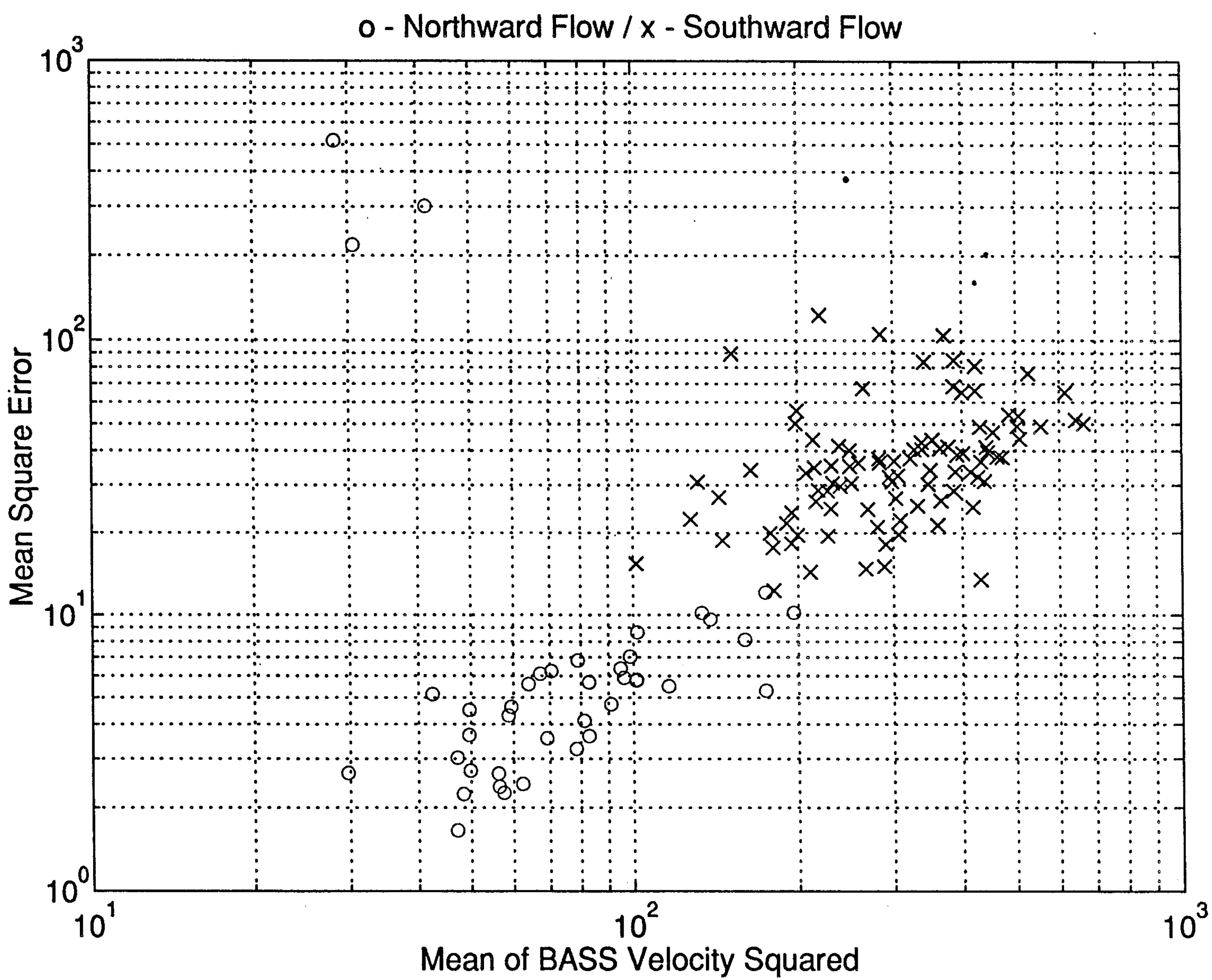
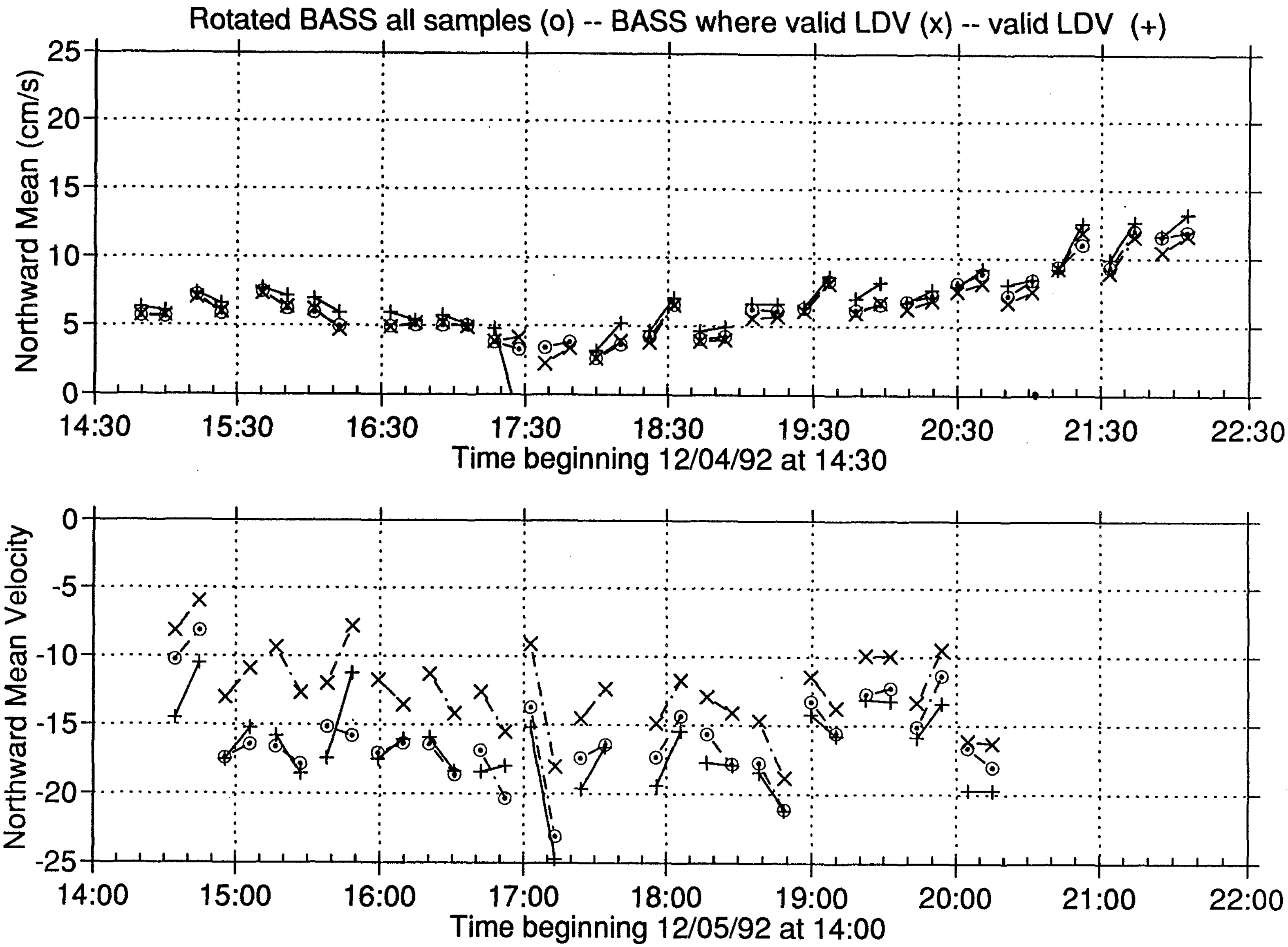

o - Northward Flow / x - Southward Flow
Mean Square Error
10^3
10^2
10^1
10^0
10^1
10^2
10^3
Mean of BASS Velocity Squared

Figure 45.



Rotated BASS all samples (o) -- BASS where valid LDV (x) -- valid LDV (+)
Northward Mean (cm/s)
25
20
15
10
5
0
14:30
15:30
16:30
17:30
18:30
19:30
20:30
21:30
22:30
Time beginning 12/04/92 at 14:30
Northward Mean Velocity
0
-5
-10
-15
-20
-25
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
Time beginning 12/05/92 at 14:00

Figure 46.

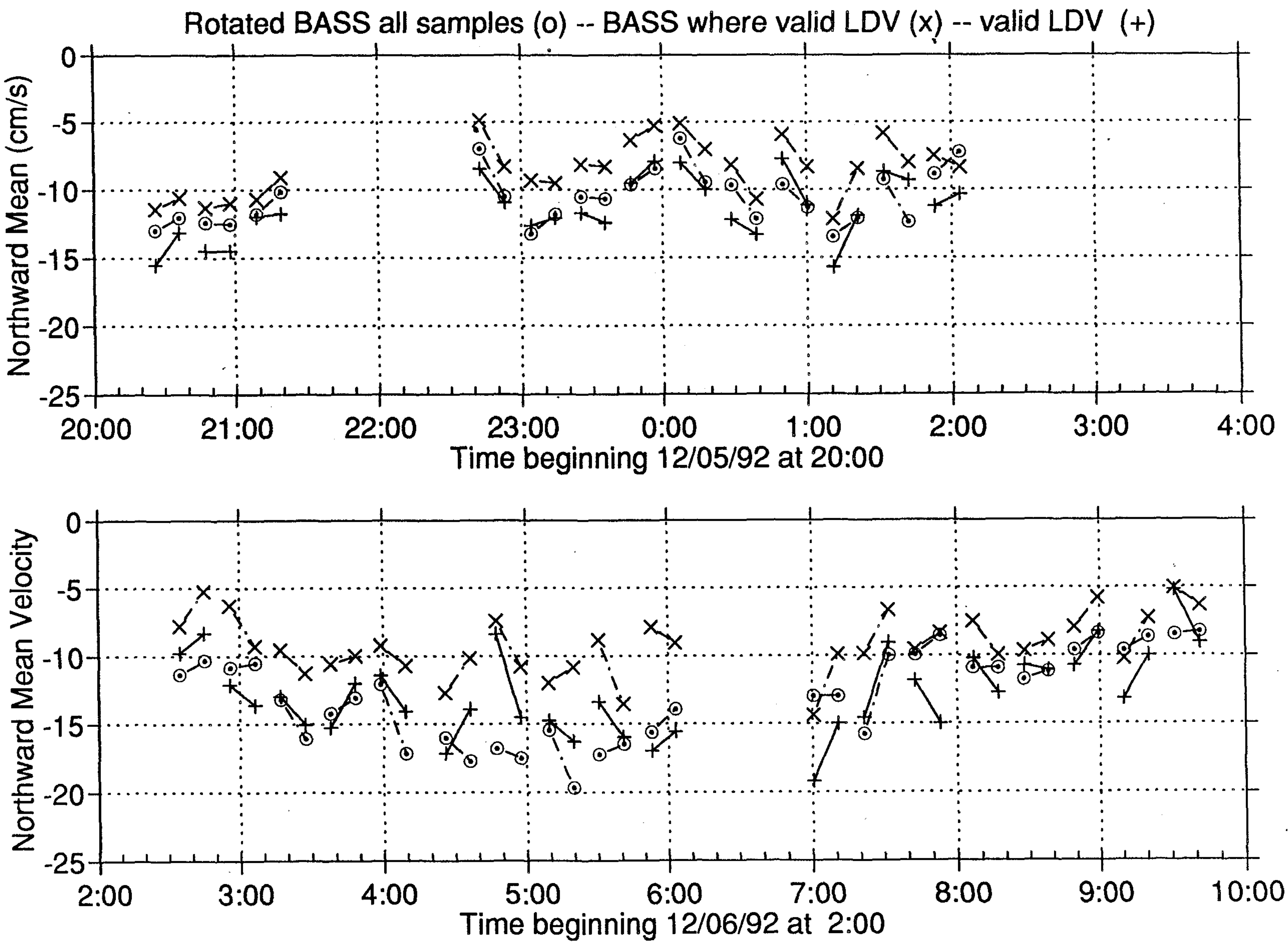
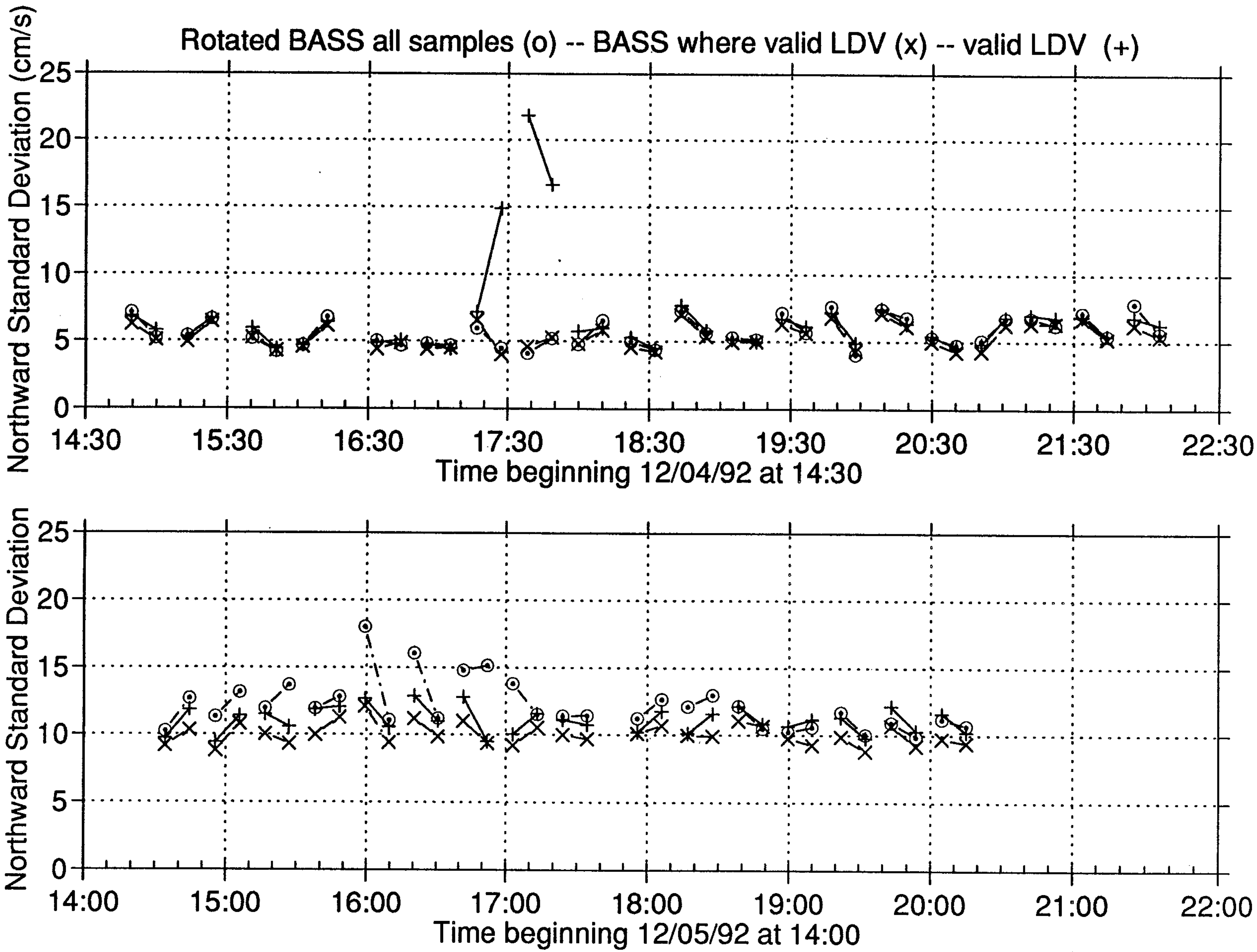

Rotated BASS all samples (o) -- BASS where valid LDV (x) -- valid LDV (+)
Northward Mean (cm/s)
0
-5
-10
-15
-20
-25
20:00
21:00
22:00
23:00
0:00
1:00
2:00
3:00
4:00
Time beginning 12/05/92 at 20:00
Northward Mean Velocity
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
Time beginning 12/06/92 at 2:00

Figure 47.



Rotated BASS all samples (o) -- BASS where valid LDV (x) -- valid LDV (+)
Northward Standard Deviation (cm/s)
0
5
10
15
20
25
14:30
15:30
16:30
17:30
18:30
19:30
20:30
21:30
22:30
Time beginning 12/04/92 at 14:30
Northward Standard Deviation
0
5
10
15
20
25
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
Time beginning 12/05/92 at 14:00

Figure 48.

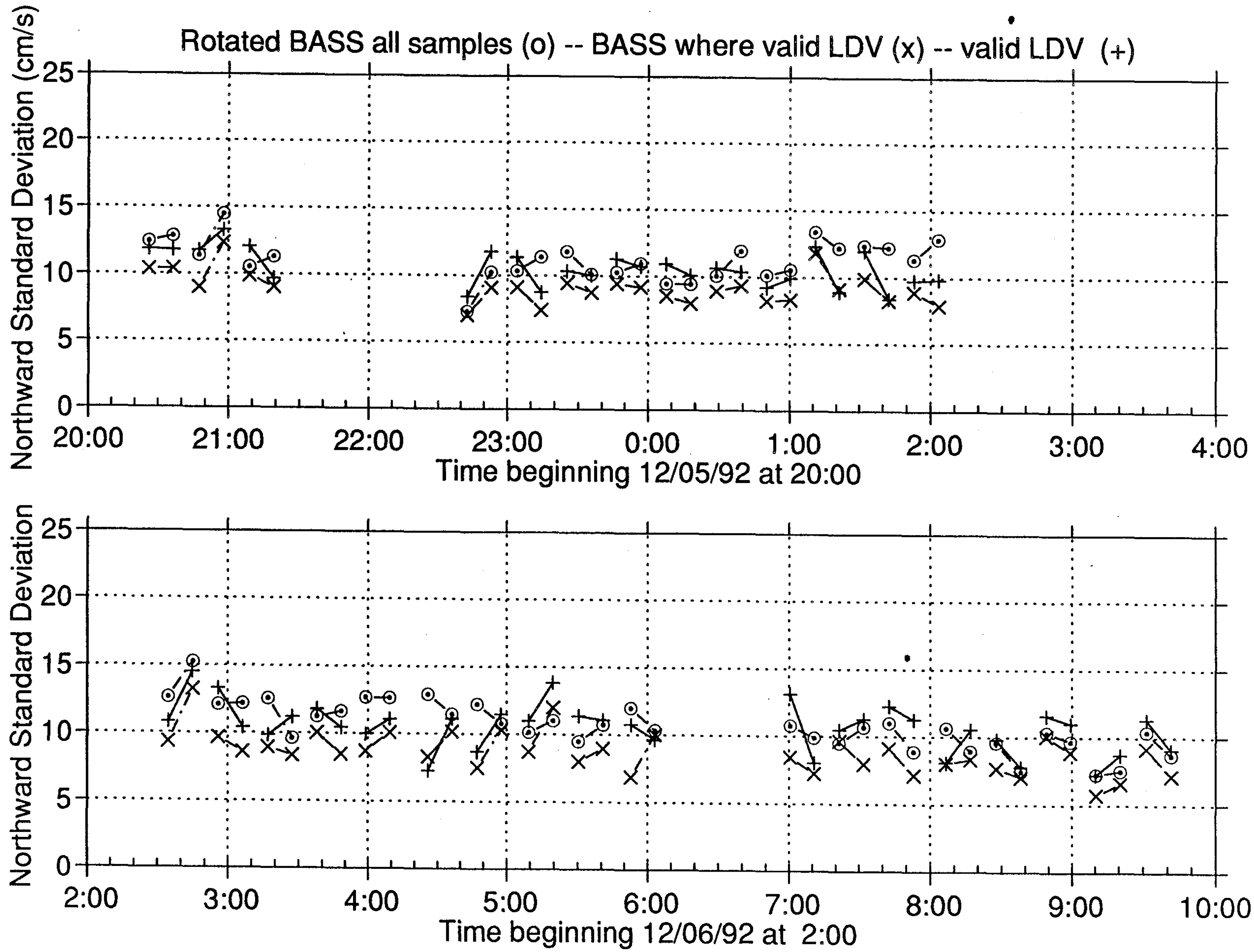

Rotated BASS all samples (o) -- BASS where valid LDV (x) -- valid LDV (+)
Northward Standard Deviation (cm/s)
25
20
15
10
5
0
20:00
21:00
22:00
23:00
0:00
1:00
2:00
3:00
4:00
Time beginning 12/05/92 at 20:00
Northward Standard Deviation
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
Time beginning 12/06/92 at 2:00

Figure 49.

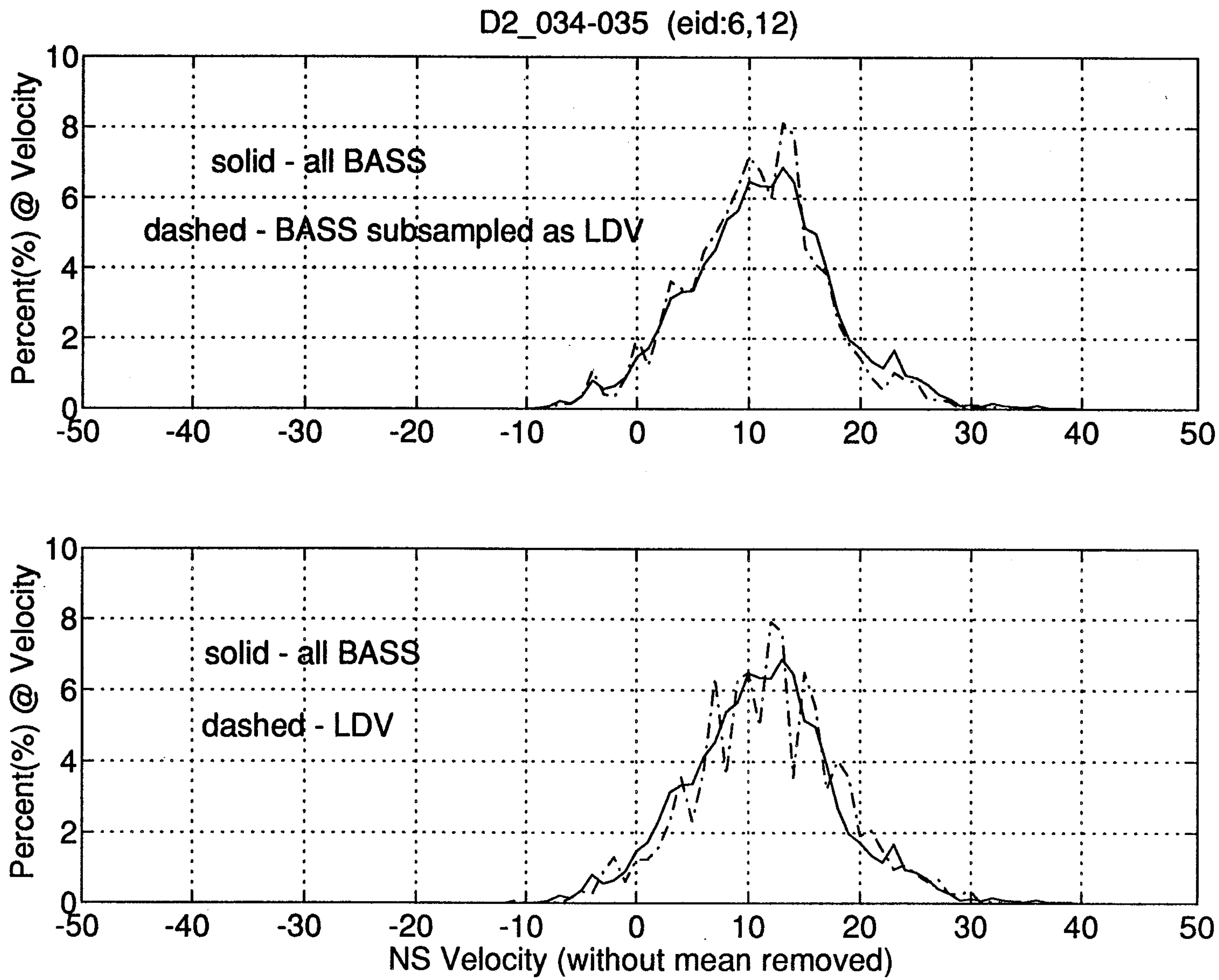

D2_034-035 (eid:6,12)
solid - all BASS
dashed - BASS subsampled as LDV
Percent(%) @ Velocity
solid - all BASS
dashed - LDV
Percent(%) @ Velocity
NS Velocity (without mean removed)

Figure 50.

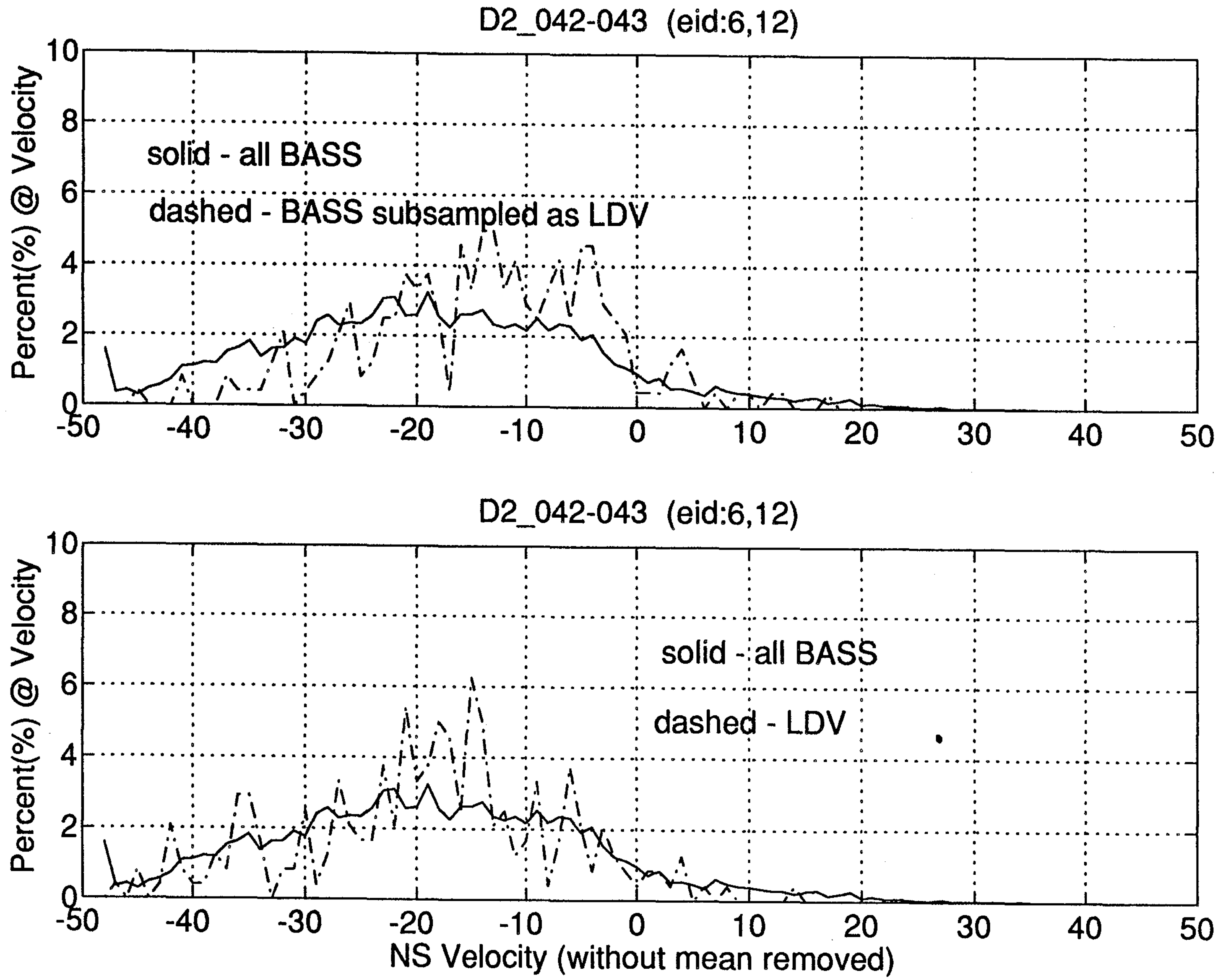

D2_042-043 (eid:6,12)
solid - all BASS
dashed - BASS subsampled as LDV
Percent(%) @ Velocity
D2_042-043 (eid:6,12)
solid - all BASS
dashed - LDV
Percent(%) @ Velocity
NS Velocity (without mean removed)

Figure 51.

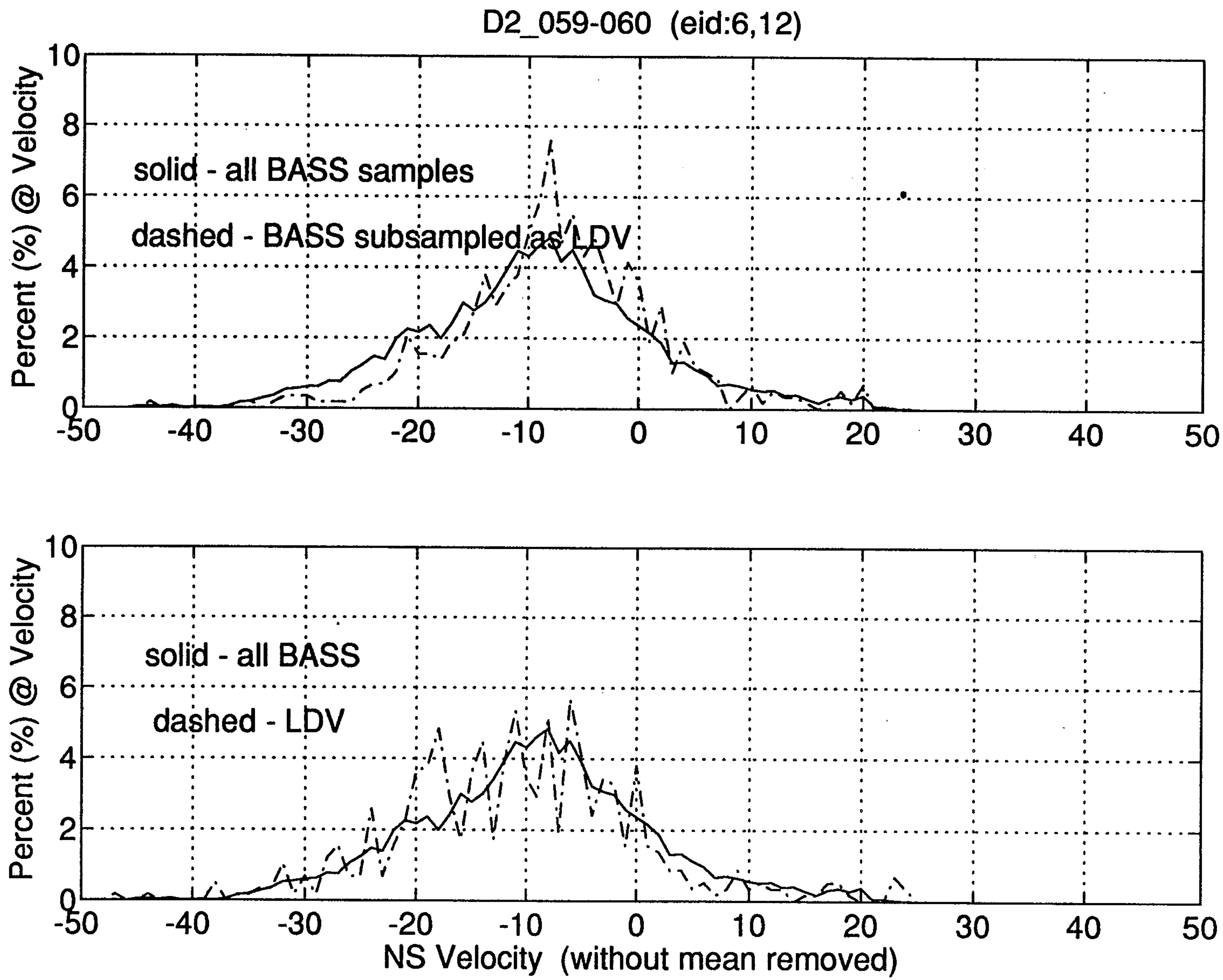
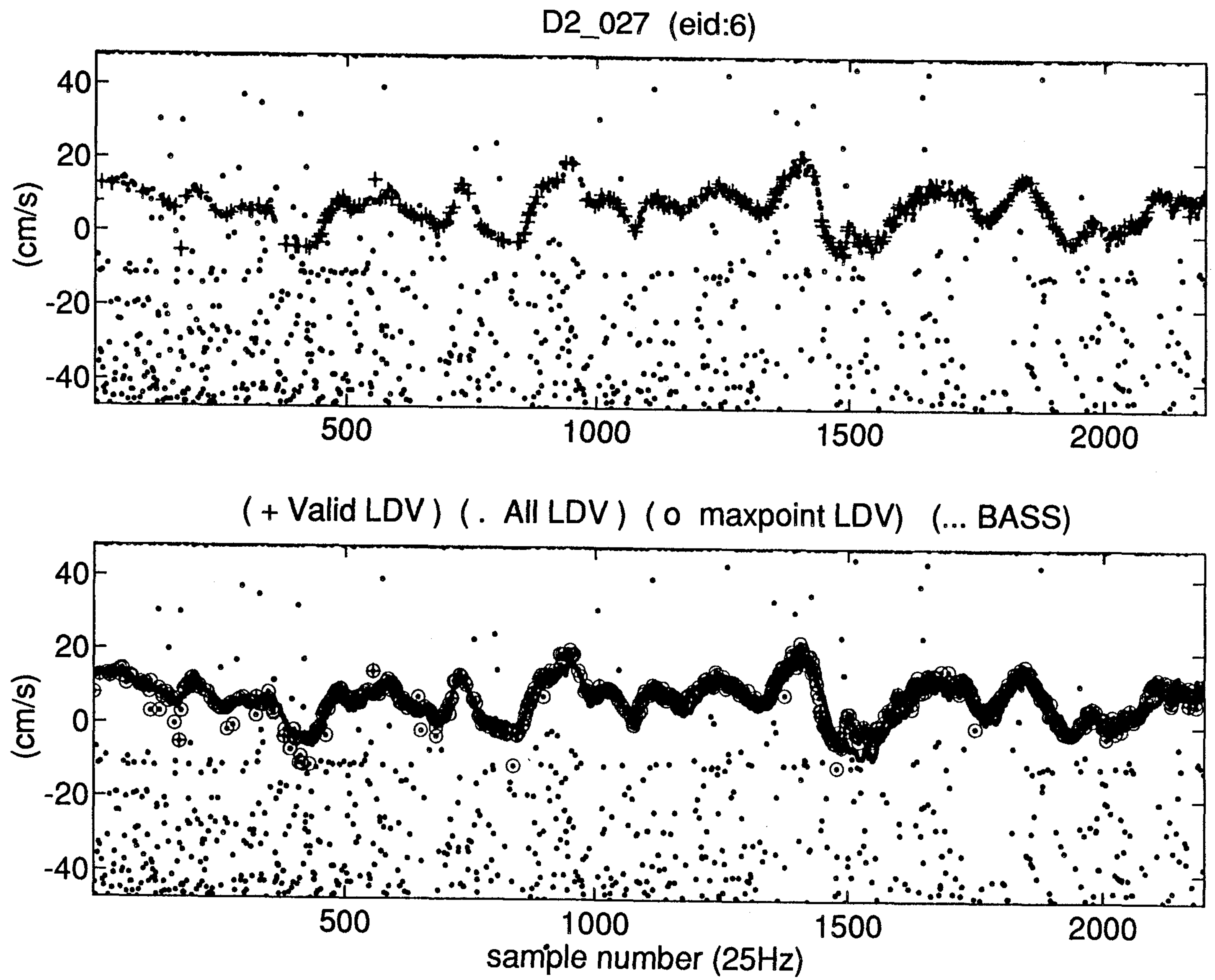

D2_059-060 (eid:6,12)
solid - all BASS samples
dashed - BASS subsampled as LDV
Percent (%) @ Velocity
10
8
6
4
2
0
-50
-40
-30
-20
-10
0
10
20
30
40
50
solid - all BASS
dashed - LDV
NS Velocity (without mean removed)

Figure 52.


D2_027 (eid:6)
(cm/s)
40
20
0
-20
-40
500
1000
1500
2000
(+ Valid LDV) (. All LDV) (o maxpoint LDV) (... BASS)
(cm/s)
sample number (25Hz)

NS

Figure 53.

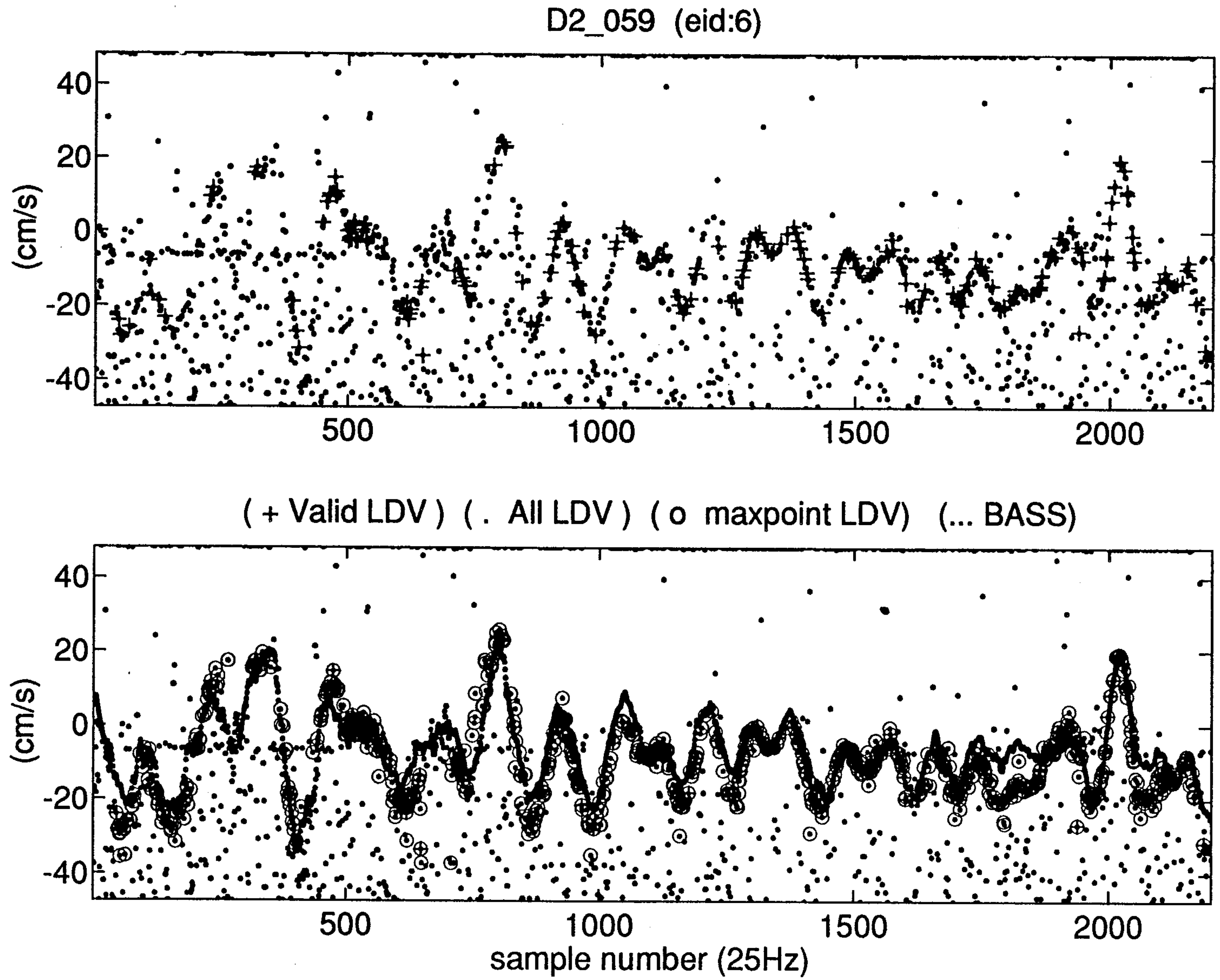

D2_059 (eid:6)
(cm/s)
40
20
0
-20
-40
500
1000
1500
2000
(+ Valid LDV) (. All LDV) (o maxpoint LDV) (... BASS)
sample number (25Hz)

Figure 54.

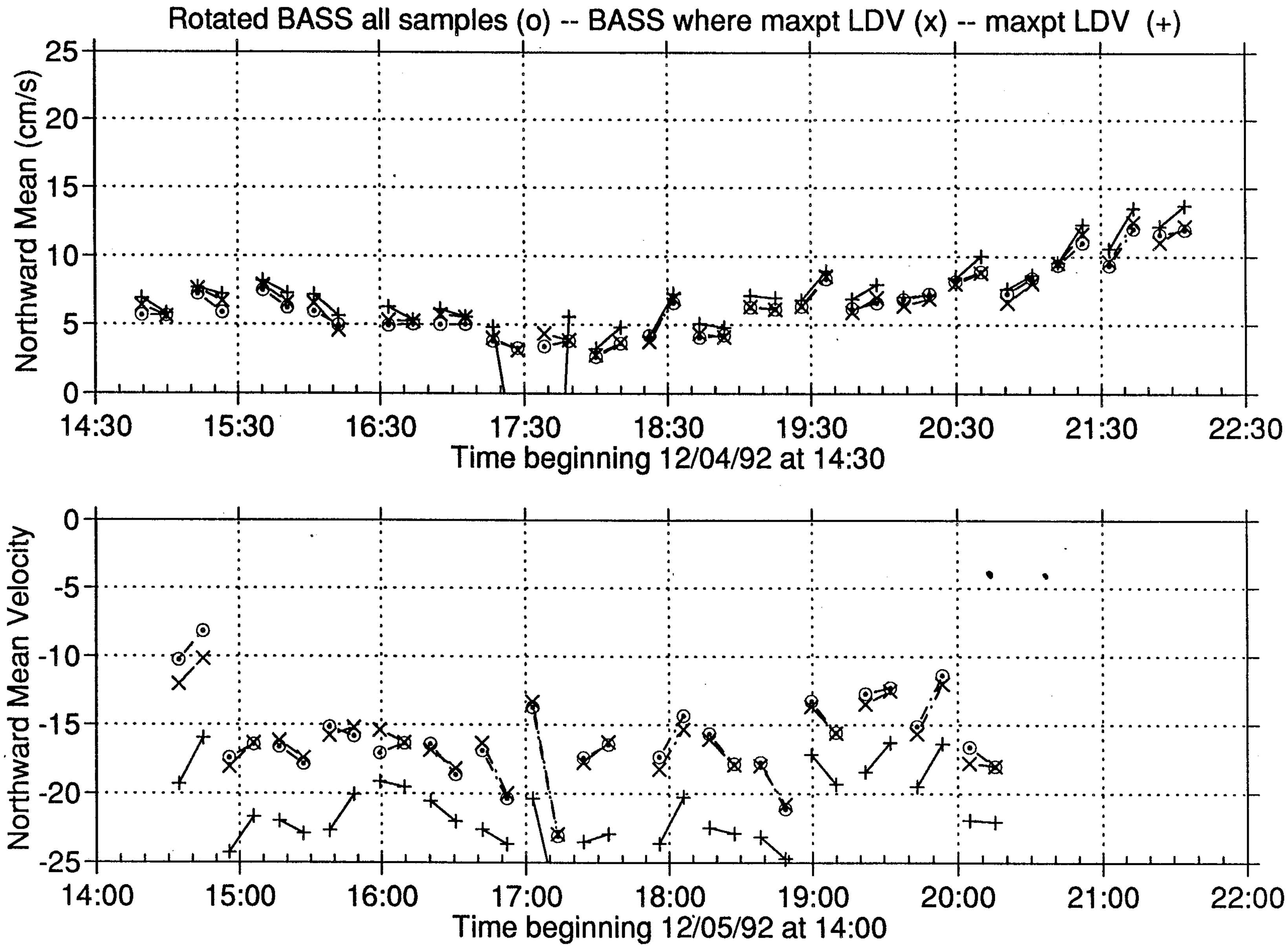
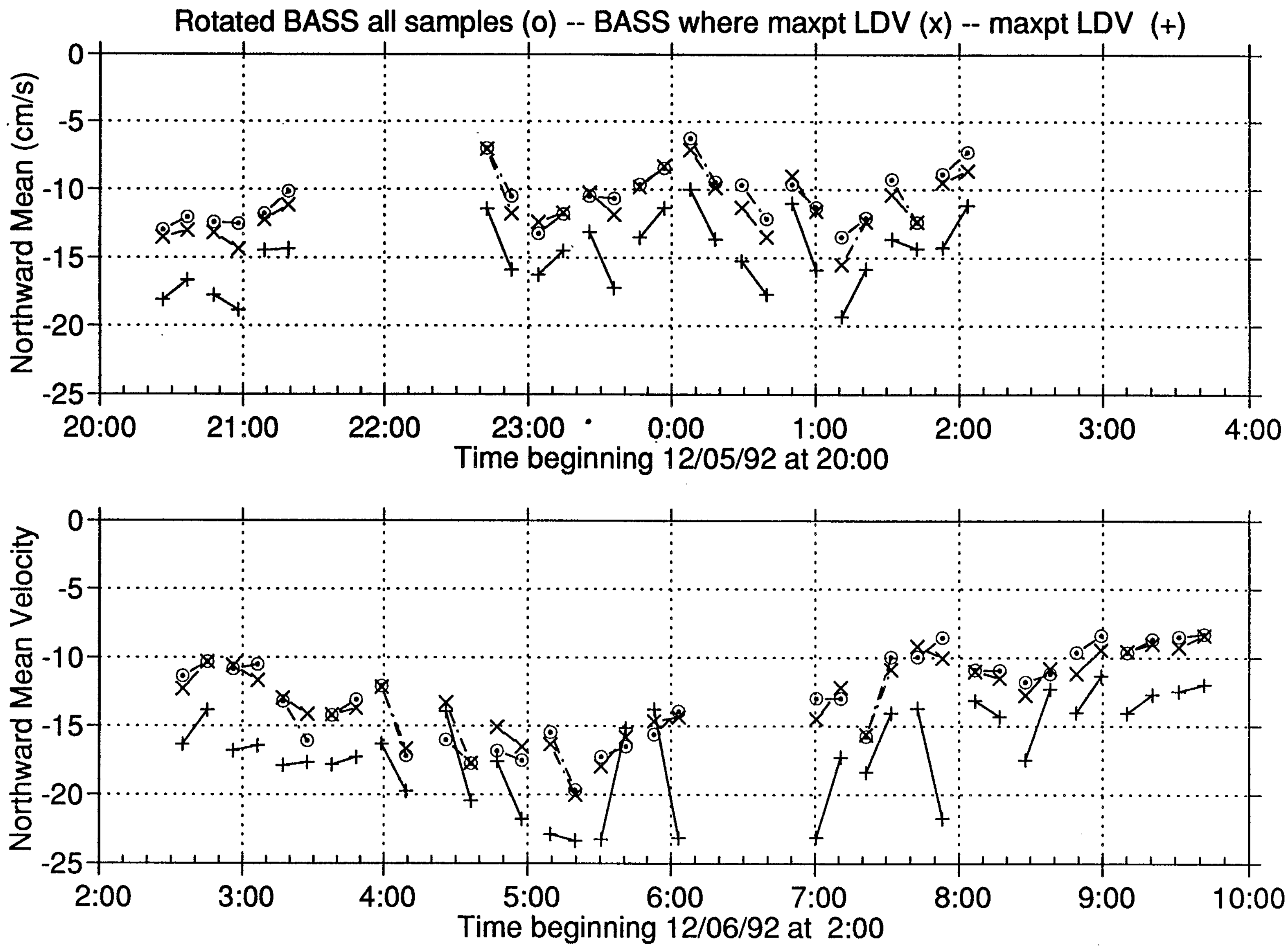

Rotated BASS all samples (o) -- BASS where maxpt LDV (x) -- maxpt LDV (+)
Northward Mean (cm/s)
25
20
15
10
5
0
14:30
15:30
16:30
17:30
18:30
19:30
20:30
21:30
22:30
Time beginning 12/04/92 at 14:30
Northward Mean Velocity
0
-5
-10
-15
-20
-25
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
Time beginning 12/05/92 at 14:00

Figure 55.



Rotated BASS all samples (o) -- BASS where maxpt LDV (x) -- maxpt LDV (+)
Northward Mean (cm/s)
0
-5
-10
-15
-20
-25
20:00
21:00
22:00
23:00
0:00
1:00
2:00
3:00
4:00
Time beginning 12/05/92 at 20:00
Northward Mean Velocity
0
-5
-10
-15
-20
-25
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
Time beginning 12/06/92 at 2:00

Figure 56.

6. DATA SUMMARY

The purpose of this section is to present the mean and standard deviation of each property measured. We have included pressure in meters of saltwater; Northward, Eastward and Upward BASS velocity data (centimeters/second); and, N-S LDV (centimeters per second) at each height. The series are primarily shown as eight hour segments. The first group includes the data from the first day of observation, when the velocity was primarily northward flow. The other three segments are divided for display purposes only and are also displayed collectively in a twenty hour window. The E-W LDV is only included for a short time period (D2_026-29), as the other data could not be recovered.

6.1 PRESSURE

The pressure data are presented with tide gage data. The tide data are taken in 8 meters of water off the pier end at the National Oceanic and Atmospheric Administration/National Ocean Service (NOAA/NOS) tide station and are hourly averages of data which had been recorded every six minutes. More detailed data are available through NOAA/NOS. The pressure data were measured at approximately 1.26 meters above bottom.

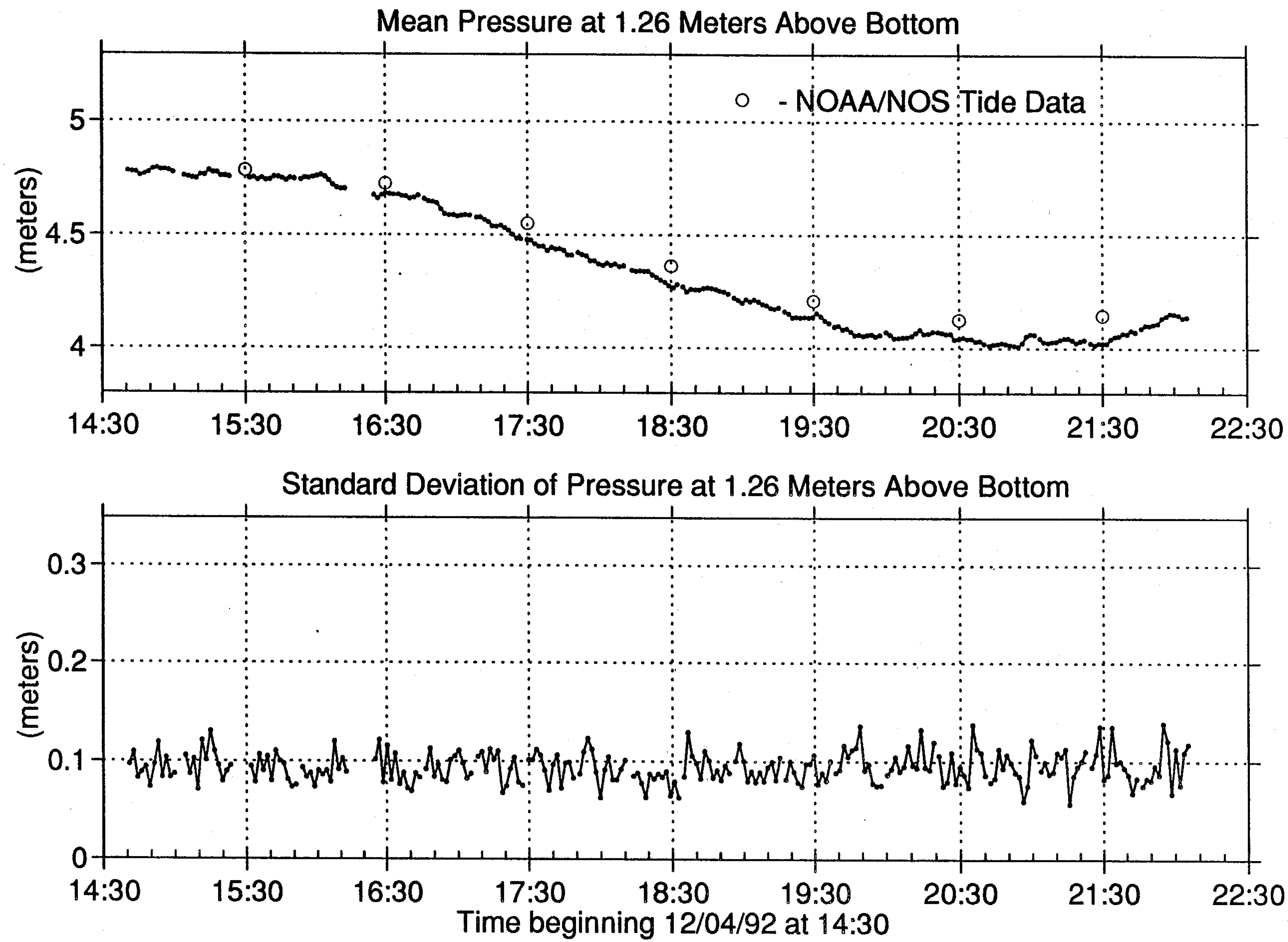
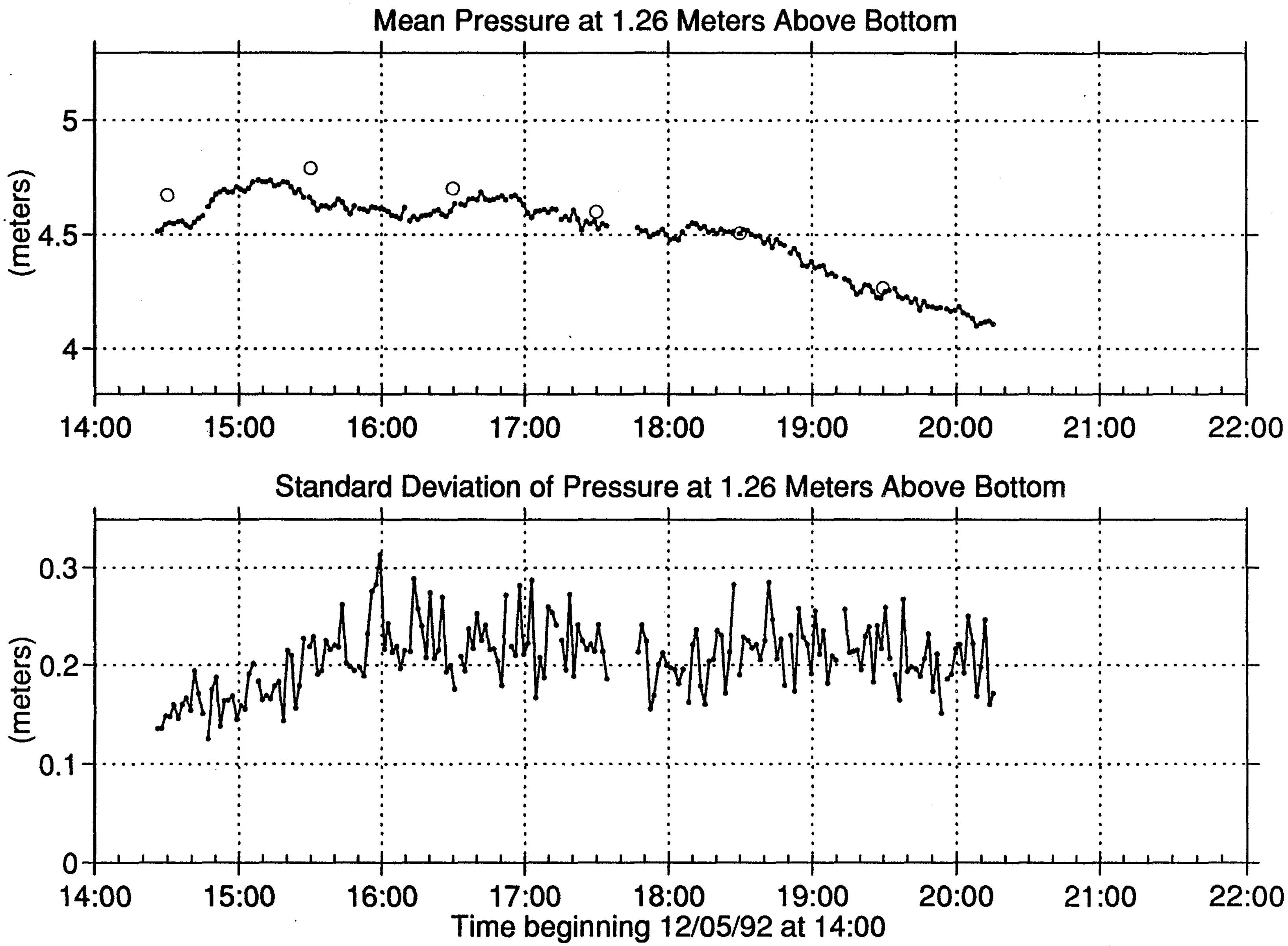

Mean Pressure at 1.26 Meters Above Bottom
- NOAA/NOS Tide Data
(meters)
5
4.5
4
14:30
15:30
16:30
17:30
18:30
19:30
20:30
21:30
22:30
Standard Deviation of Pressure at 1.26 Meters Above Bottom
(meters)
0.3
0.2
0.1
0
Time beginning 12/04/92 at 14:30

Figure 57.



Mean Pressure at 1.26 Meters Above Bottom
(meters)
5
4.5
4
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
Standard Deviation of Pressure at 1.26 Meters Above Bottom
(meters)
0.3
0.2
0.1
0
Time beginning 12/05/92 at 14:00

Figure 58.

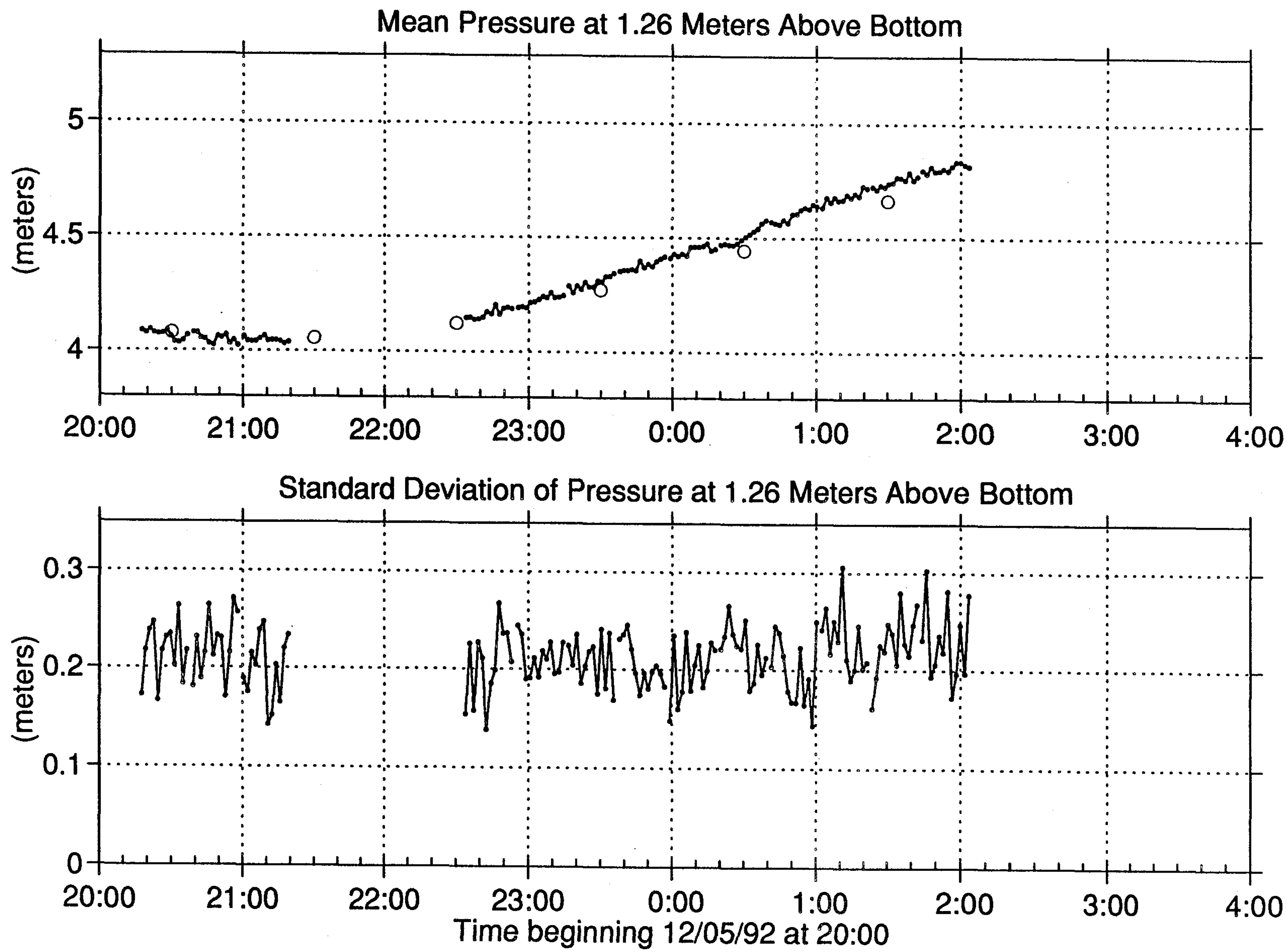

Mean Pressure at 1.26 Meters Above Bottom
(meters)
5
4.5
4
20:00
21:00
22:00
23:00
0:00
1:00
2:00
3:00
4:00
Standard Deviation of Pressure at 1.26 Meters Above Bottom
(meters)
0.3
0.2
0.1
0
Time beginning 12/05/92 at 20:00

Figure 59.

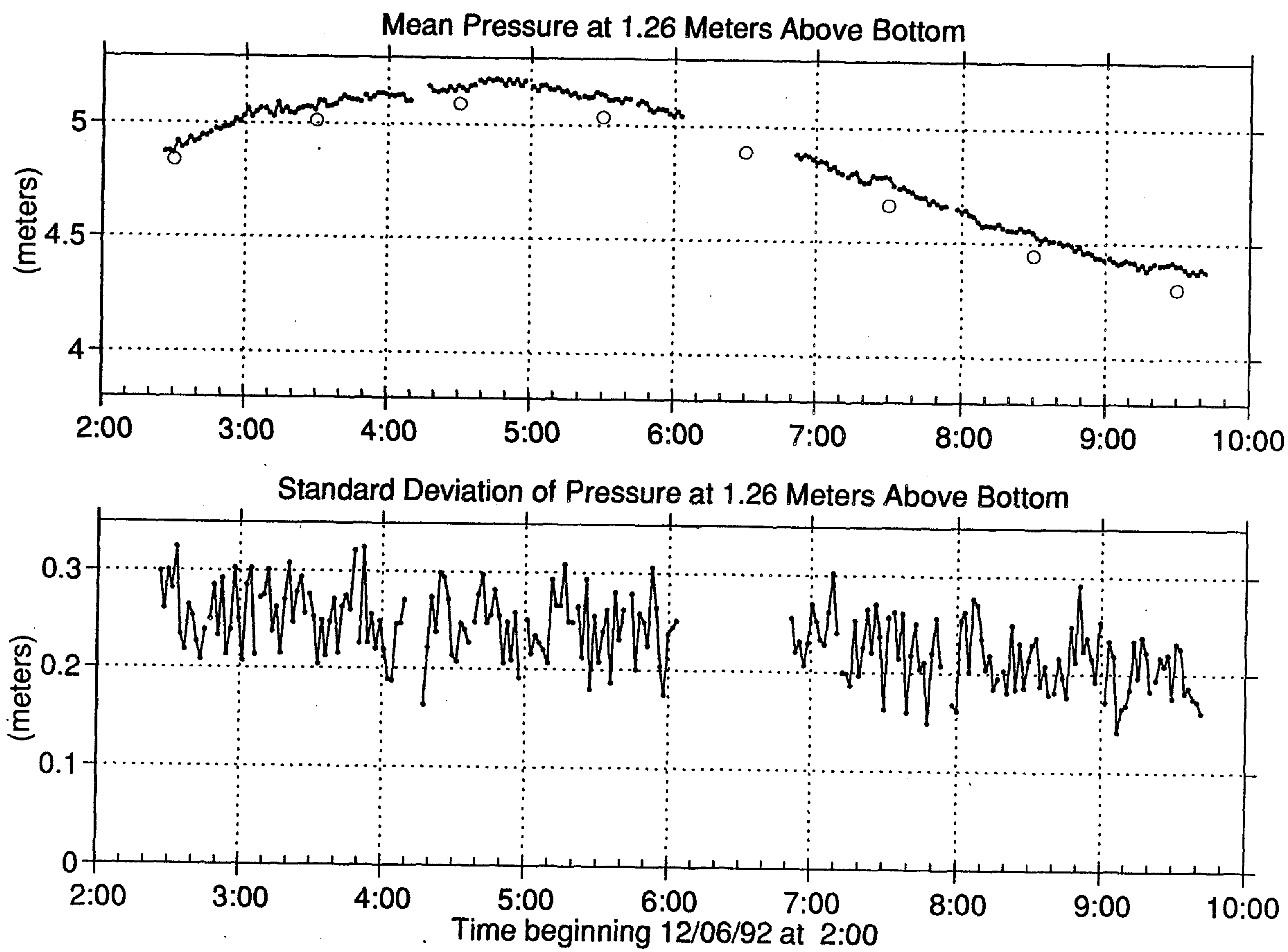
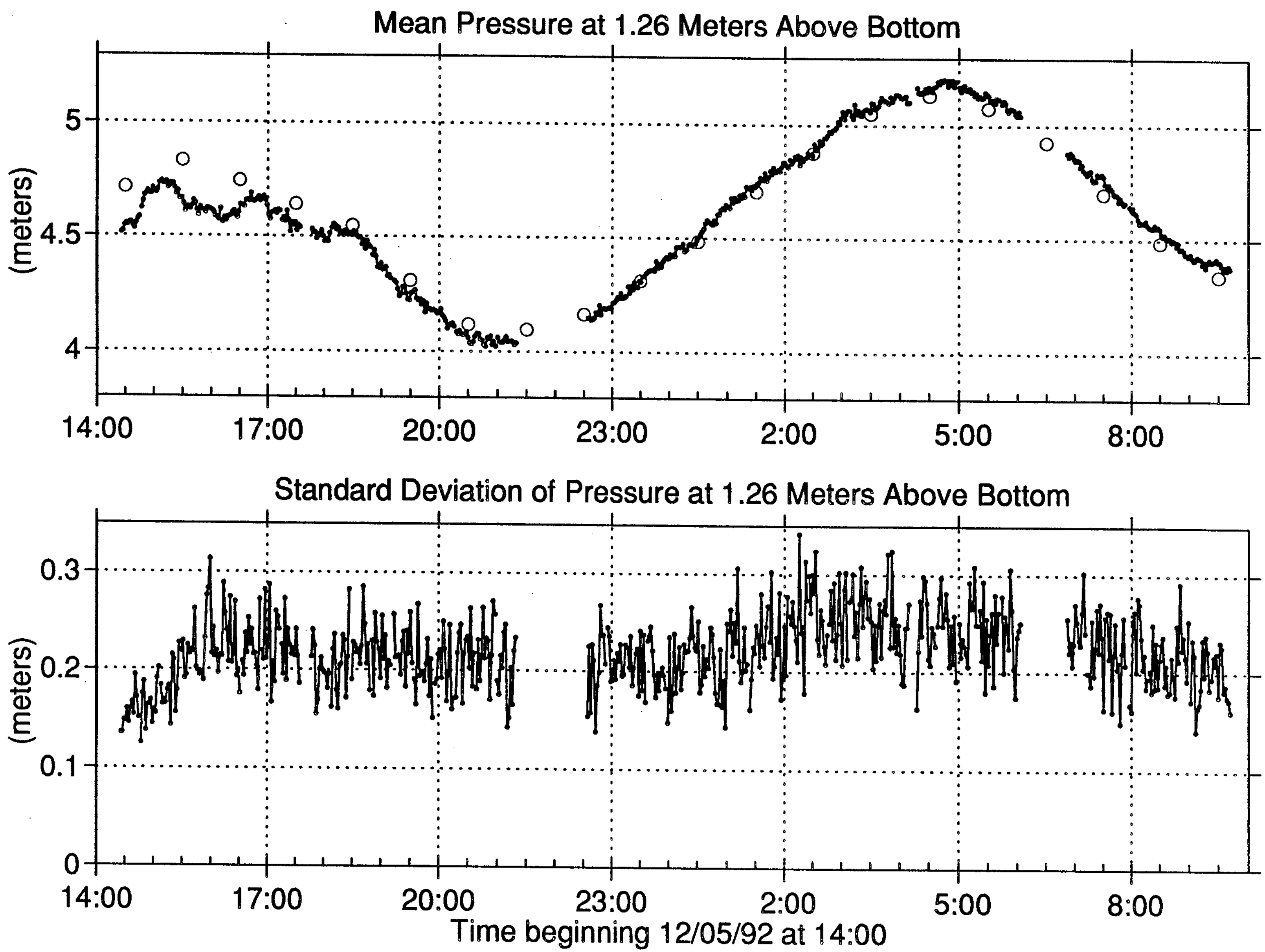

Mean Pressure at 1.26 Meters Above Bottom
(meters)
5
4.5
4
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
Standard Deviation of Pressure at 1.26 Meters Above Bottom
(meters)
0.3
0.2
0.1
0
Time beginning 12/06/92 at 2:00

Figure 60.

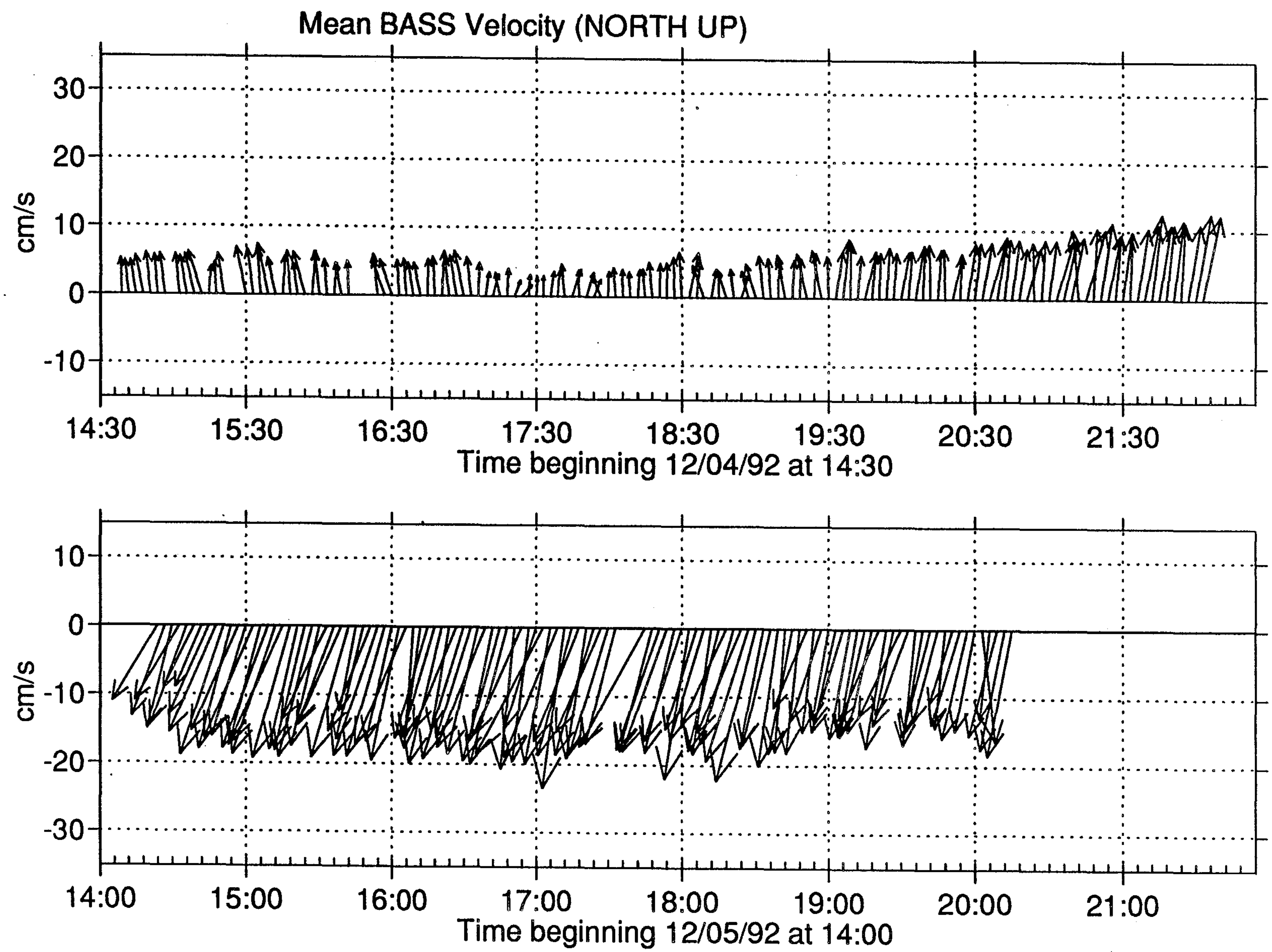


Mean Pressure at 1.26 Meters Above Bottom
(meters)
5
4.5
4
14:00
17:00
20:00
23:00
2:00
5:00
8:00
Standard Deviation of Pressure at 1.26 Meters Above Bottom
(meters)
0.3
0.2
0.1
0
Time beginning 12/05/92 at 14:00

Figure 61.

6.2 BASS VELOCITY DATA

The BASS data are presented as stickplots of Northward and Eastward velocities along with each component of the BASS velocity data. These data are **not rotated** and 'Northward' refers to Magnetic North, as shown in Figure 3. The mean and standard deviation of each interpolated 25 Hz data record are shown. There were no drop-outs in the original data but outliers were replaced with interpolated data, as described in Section 4. The BASS sampling volume was at approximately 21 cm above bottom.



Mean BASS Velocity (NORTH UP)
cm/s
30
20
10
0
-10
14:30
15:30
16:30
17:30
18:30
19:30
20:30
21:30
Time beginning 12/04/92 at 14:30
cm/s
10
0
-10
-20
-30
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
Time beginning 12/05/92 at 14:00

Figure 62.

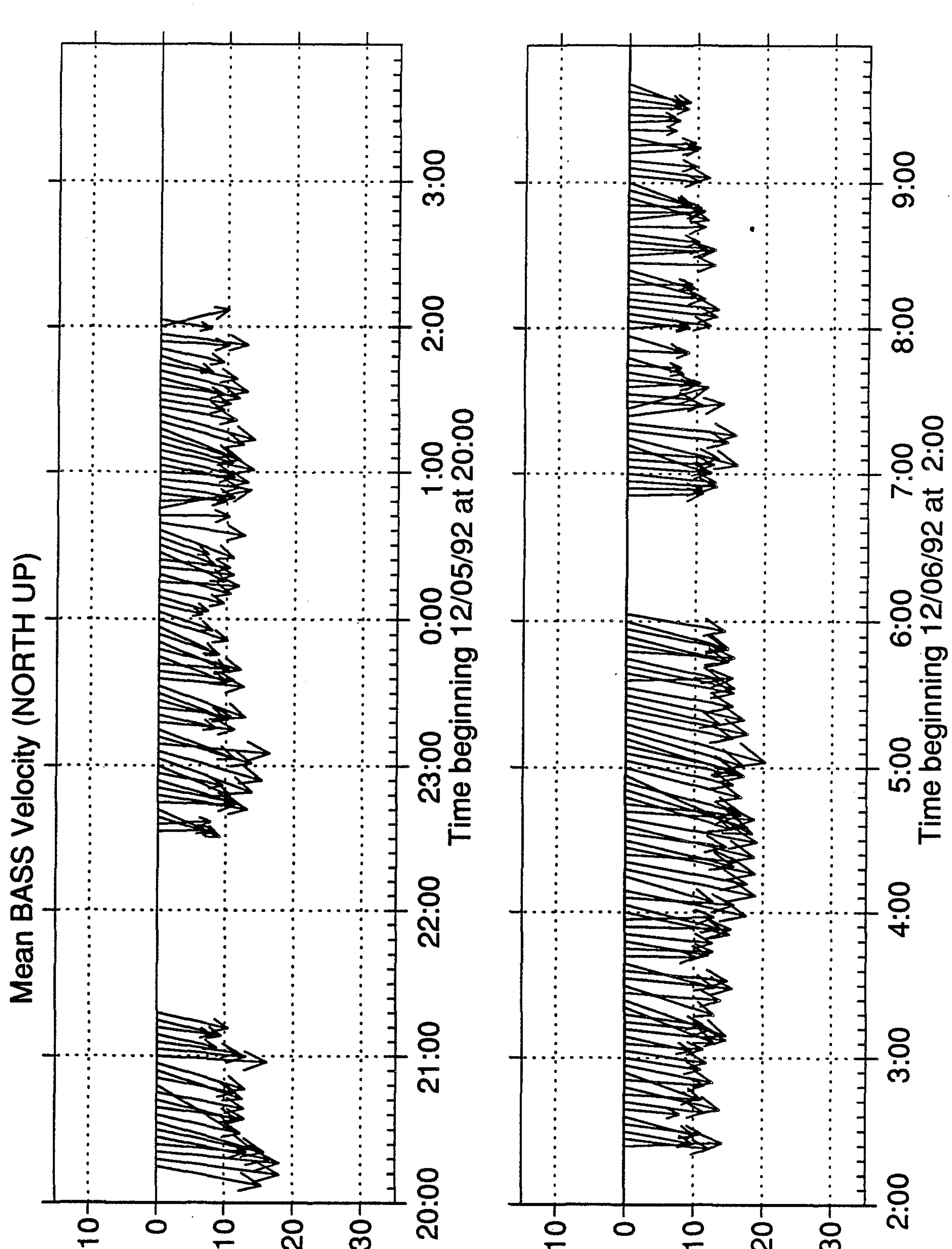

Mean BASS Velocity (NORTH UP)
cm/s
10
0
-10
-20
-30
20:00
21:00
22:00
23:00
0:00
1:00
2:00
3:00
Time beginning 12/05/92 at 20:00
cm/s
10
0
-10
-20
-30
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
Time beginning 12/06/92 at 2:00

Figure 63.

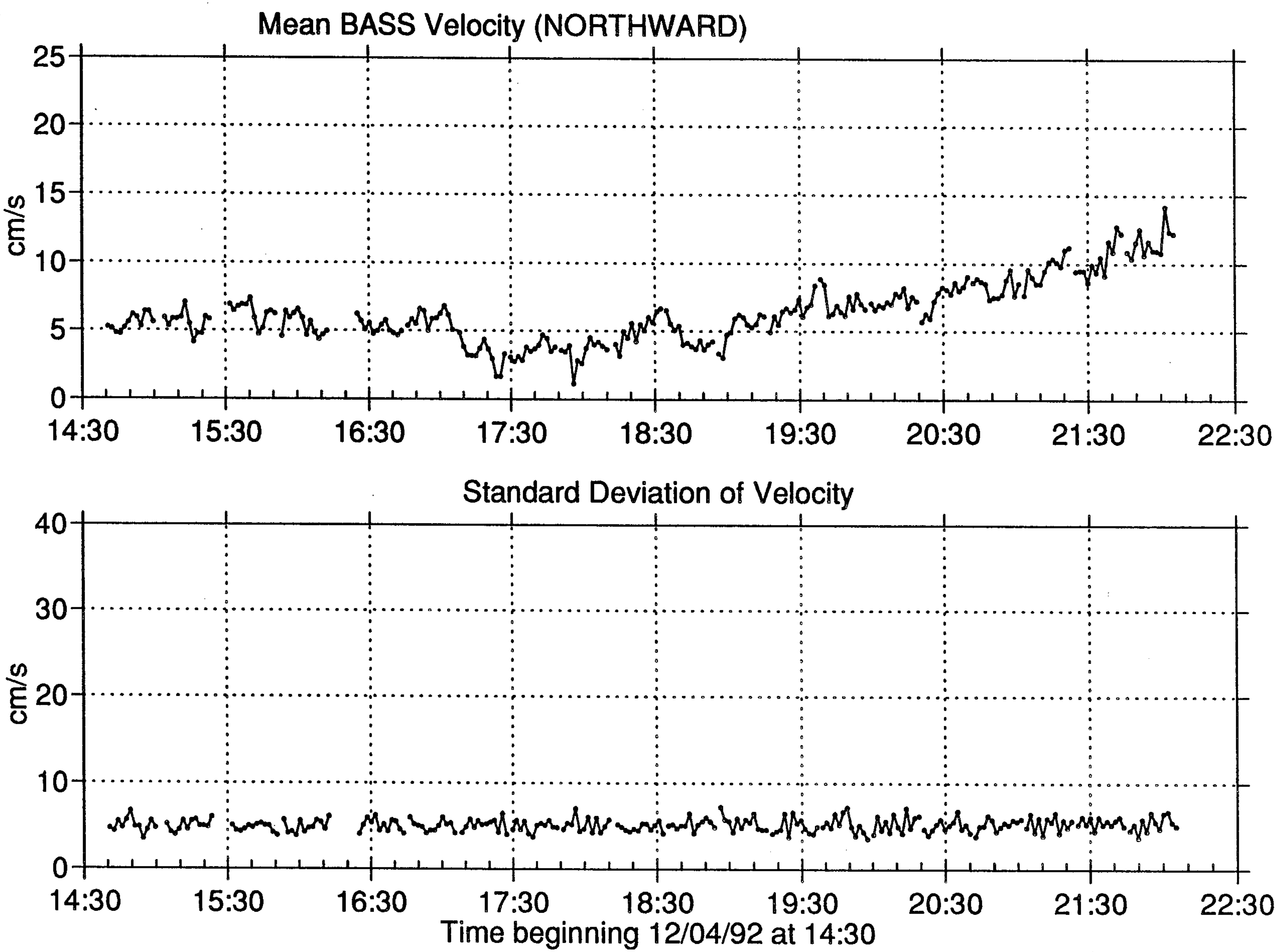
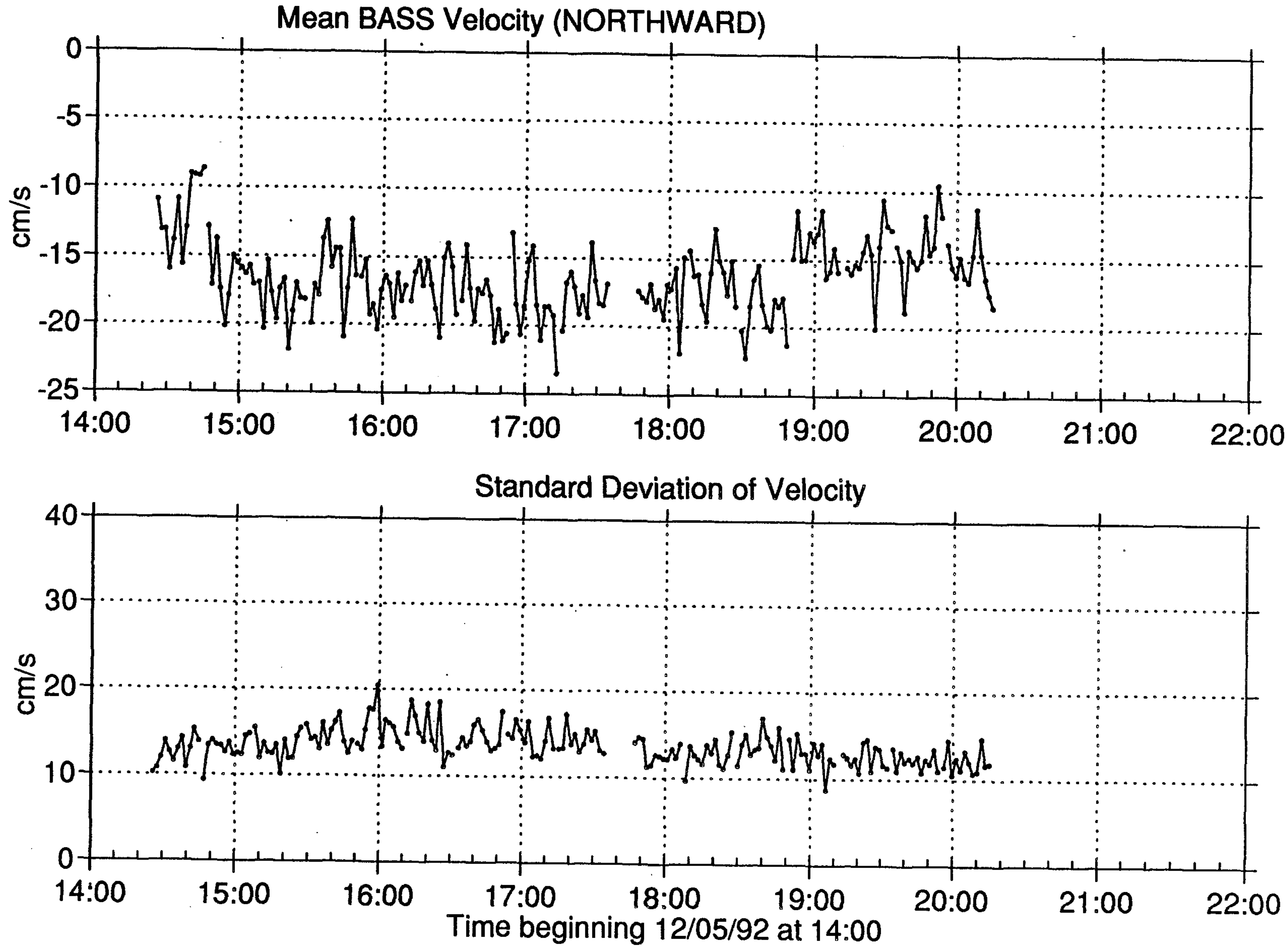

Mean BASS Velocity (NORTHWARD)
cm/s
25
20
15
10
5
0
14:30
15:30
16:30
17:30
18:30
19:30
20:30
21:30
22:30
Standard Deviation of Velocity
cm/s
40
30
20
10
0
14:30
15:30
16:30
17:30
18:30
19:30
20:30
21:30
22:30
Time beginning 12/04/92 at 14:30

Figure 64.



Mean BASS Velocity (NORTHWARD)
cm/s
0
-5
-10
-15
-20
-25
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
Standard Deviation of Velocity
cm/s
40
30
20
10
0
Time beginning 12/05/92 at 14:00

Figure 65.

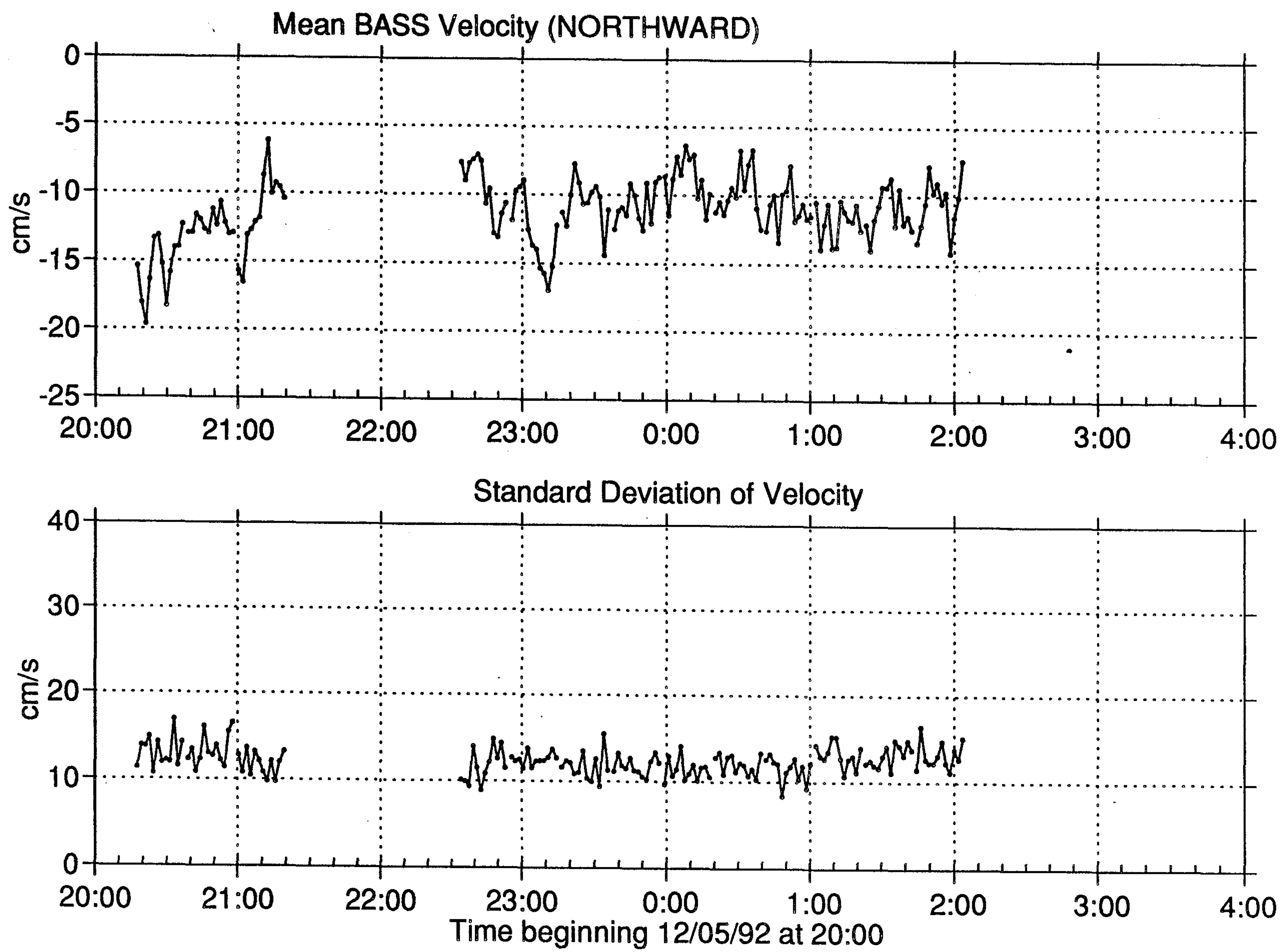
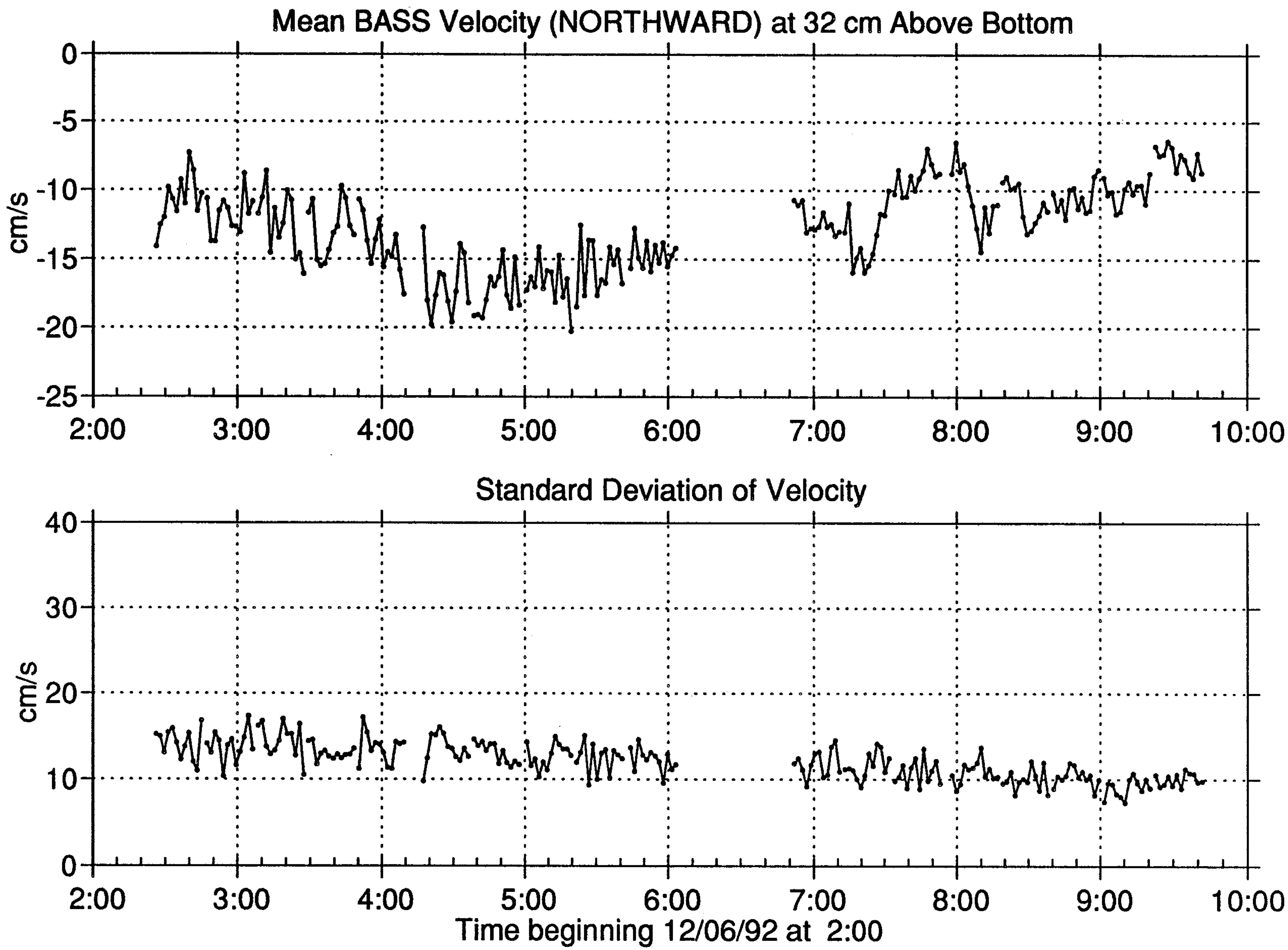
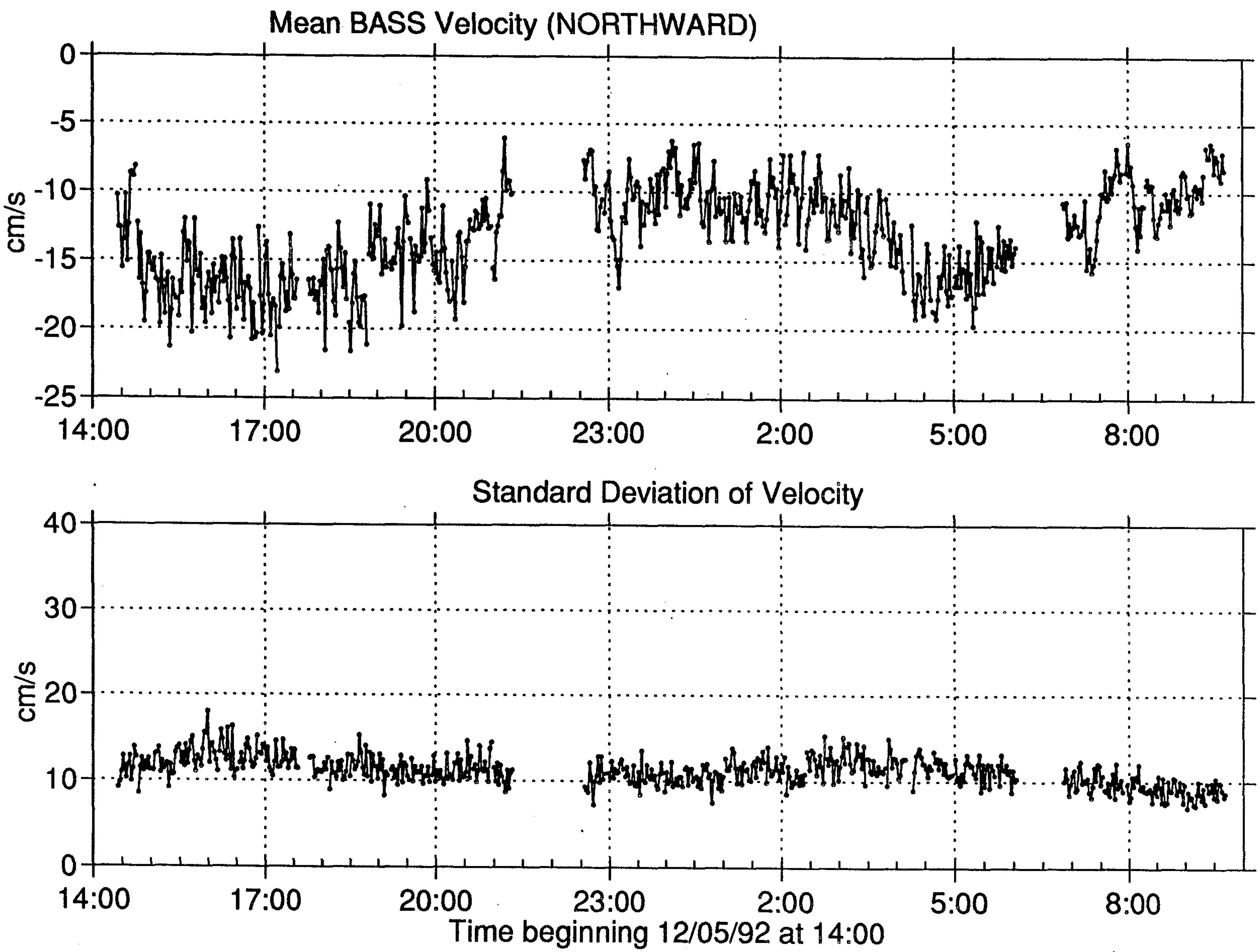

Mean BASS Velocity (NORTHWARD)
cm/s
0
-5
-10
-15
-20
-25
20:00
21:00
22:00
23:00
0:00
1:00
2:00
3:00
4:00
Standard Deviation of Velocity
cm/s
40
30
20
10
0
Time beginning 12/05/92 at 20:00

Figure 66.



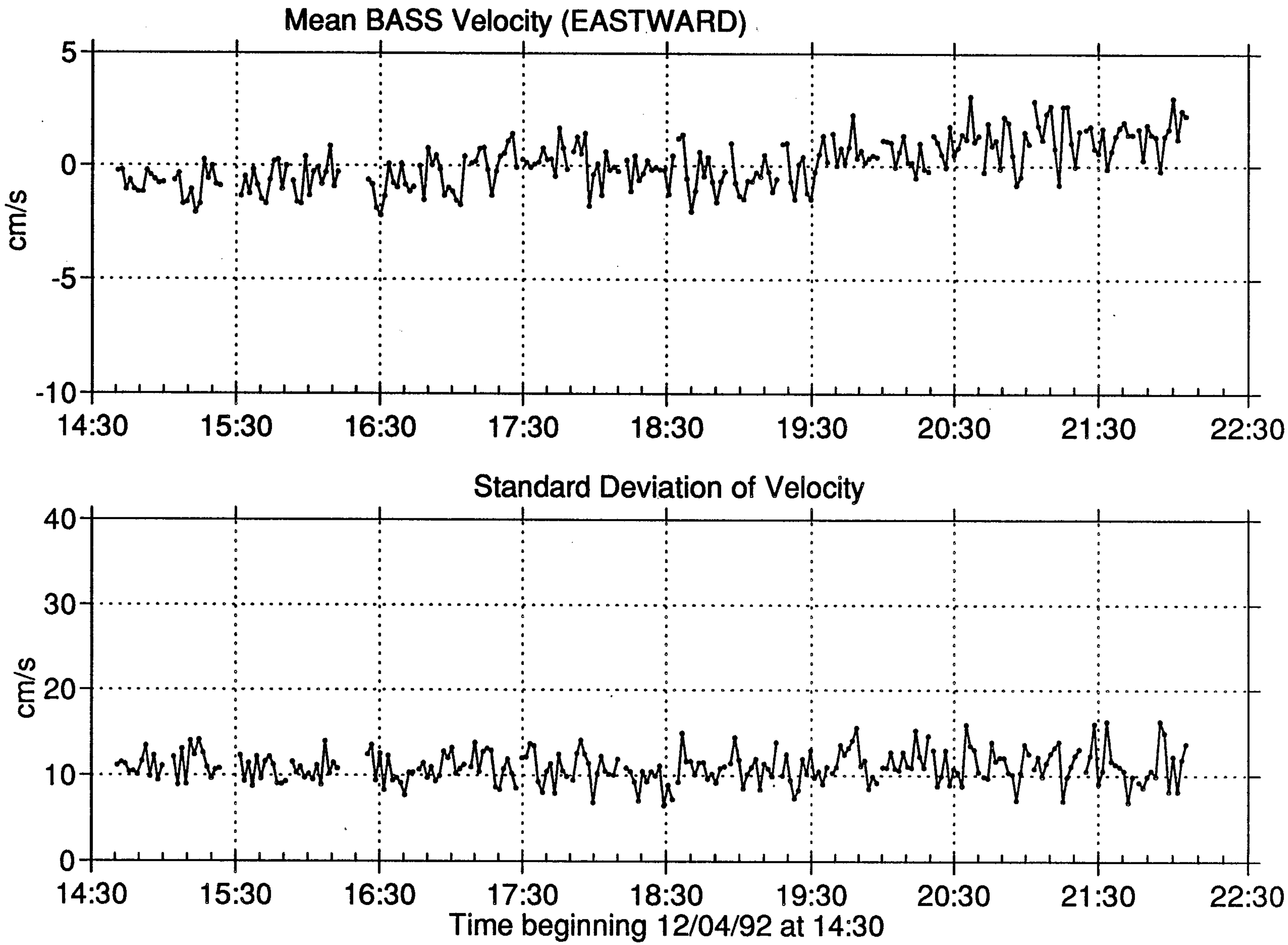
Mean BASS Velocity (NORTHWARD) at 32 cm Above Bottom
cm/s
0
-5
-10
-15
-20
-25
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
Standard Deviation of Velocity
cm/s
40
30
20
10
0
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
Time beginning 12/06/92 at 2:00

Figure 67.



Mean BASS Velocity (NORTHWARD)
cm/s
0
-5
-10
-15
-20
-25
14:00
17:00
20:00
23:00
2:00
5:00
8:00
Standard Deviation of Velocity
cm/s
40
30
20
10
0
14:00
17:00
20:00
23:00
2:00
5:00
8:00
Time beginning 12/05/92 at 14:00

Figure 68.



Mean BASS Velocity (EASTWARD)
cm/s
5
0
-5
-10
14:30
15:30
16:30
17:30
18:30
19:30
20:30
21:30
22:30
Standard Deviation of Velocity
cm/s
40
30
20
10
0
14:30
15:30
16:30
17:30
18:30
19:30
20:30
21:30
22:30
Time beginning 12/04/92 at 14:30

Figure 69.

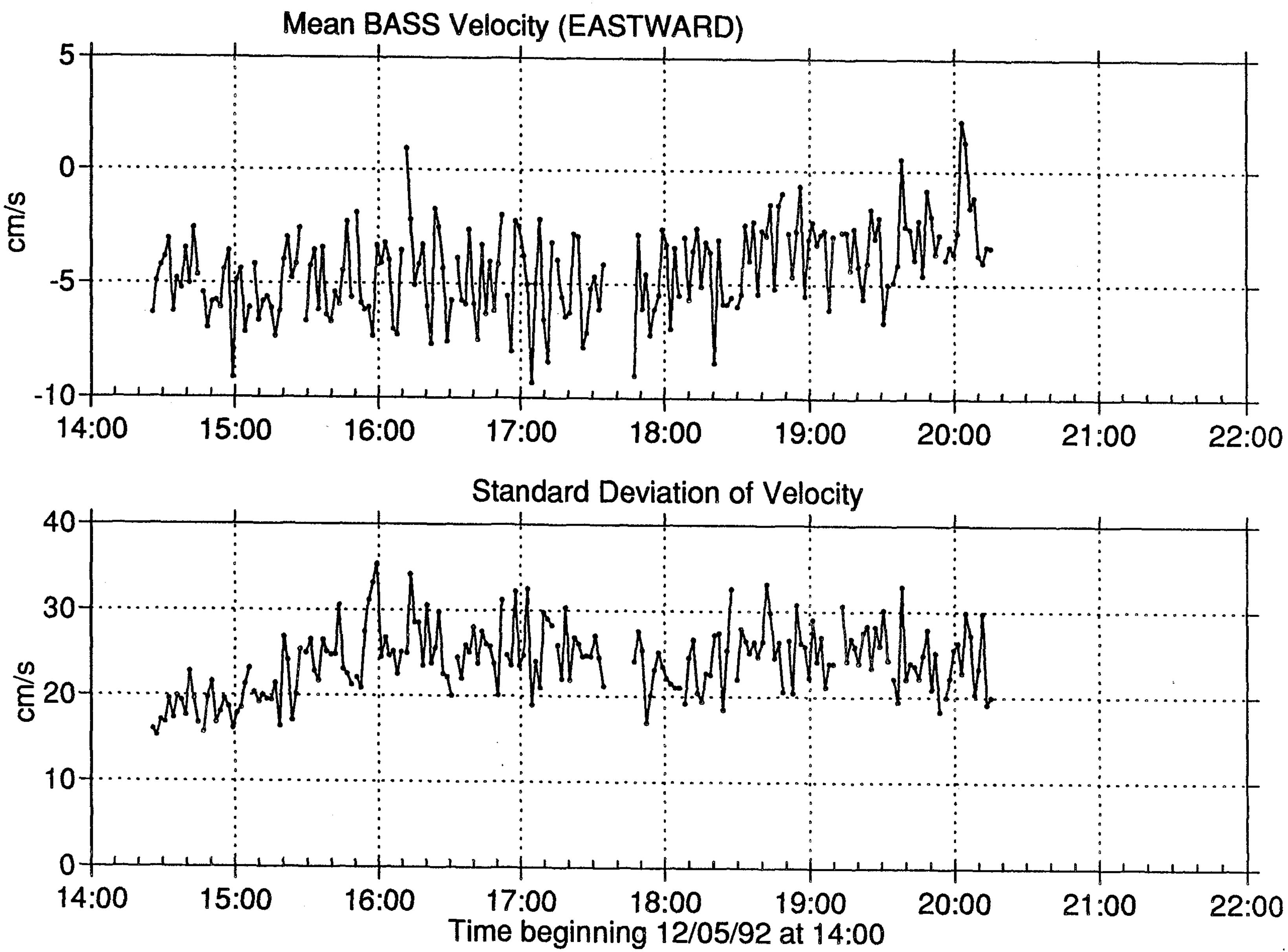
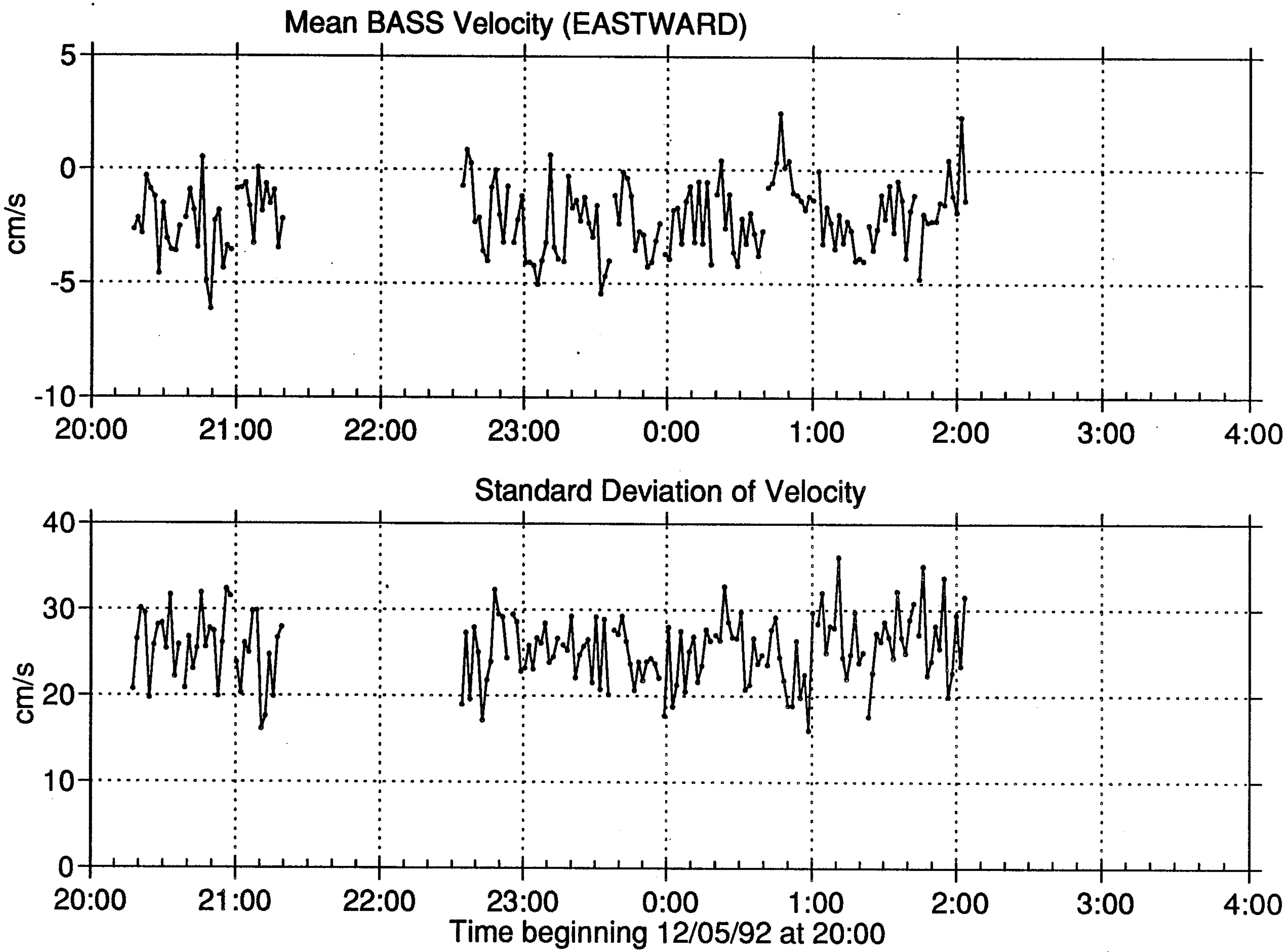
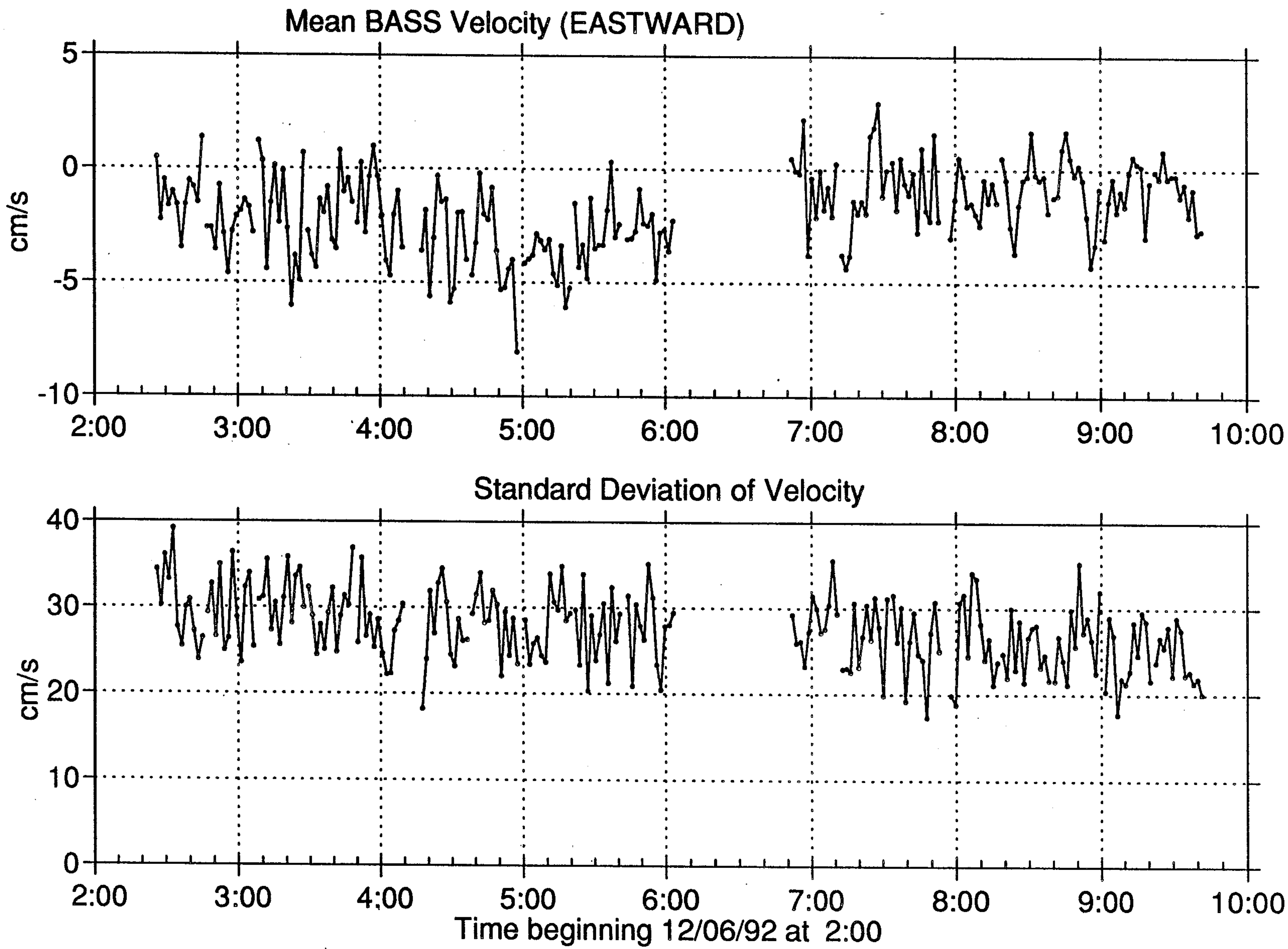

Mean BASS Velocity (EASTWARD)
cm/s
5
0
-5
-10
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
Standard Deviation of Velocity
40
30
20
10
0
Time beginning 12/05/92 at 14:00

Figure 70.



Mean BASS Velocity (EASTWARD)
cm/s
5
0
-5
-10
20:00
21:00
22:00
23:00
0:00
1:00
2:00
3:00
4:00
Standard Deviation of Velocity
cm/s
40
30
20
10
0
20:00
21:00
22:00
23:00
0:00
1:00
2:00
3:00
4:00
Time beginning 12/05/92 at 20:00

Figure 71.



Mean BASS Velocity (EASTWARD)
cm/s
5
0
-5
-10
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
Standard Deviation of Velocity
cm/s
40
30
20
10
0
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
Time beginning 12/06/92 at 2:00

Figure 72.

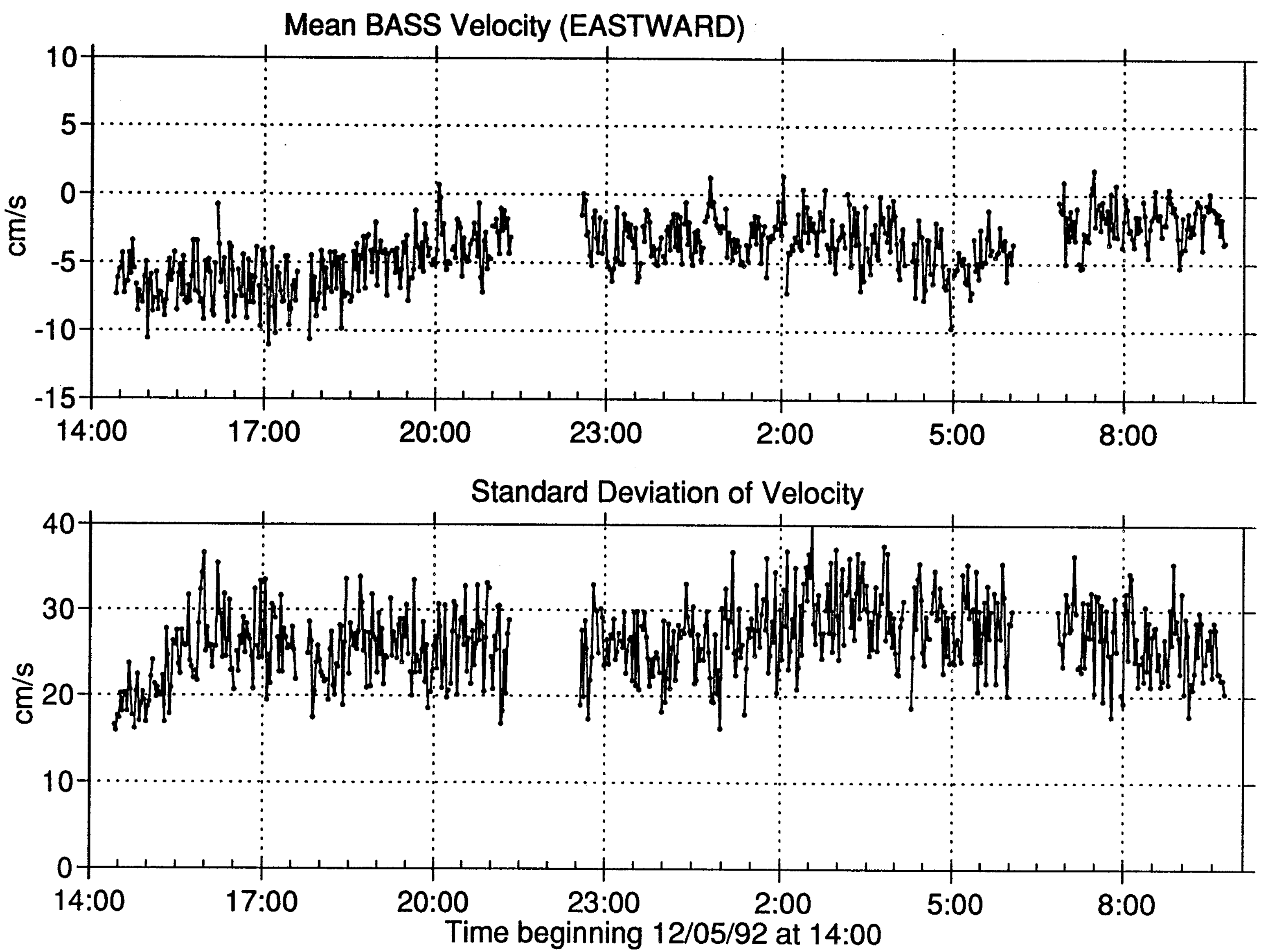
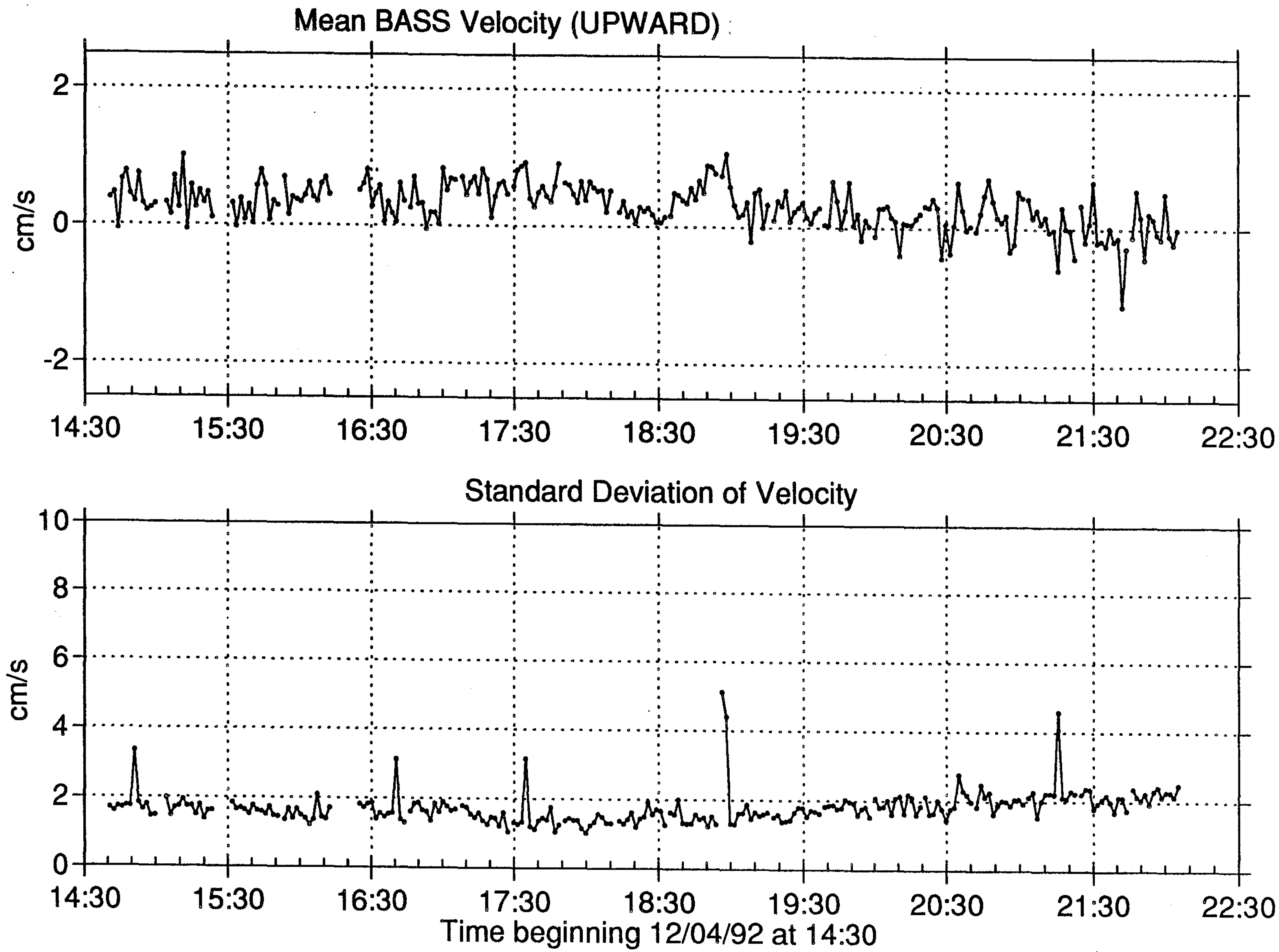

Mean BASS Velocity (EASTWARD)
cm/s
10
5
0
-5
-10
-15
14:00
17:00
20:00
23:00
2:00
5:00
8:00
Standard Deviation of Velocity
cm/s
40
30
20
10
0
14:00
17:00
20:00
23:00
2:00
5:00
8:00
Time beginning 12/05/92 at 14:00

Figure 73.



Mean BASS Velocity (UPWARD)
cm/s
2
0
-2
14:30
15:30
16:30
17:30
18:30
19:30
20:30
21:30
22:30
Standard Deviation of Velocity
cm/s
10
8
6
4
2
0
Time beginning 12/04/92 at 14:30

Figure 74.

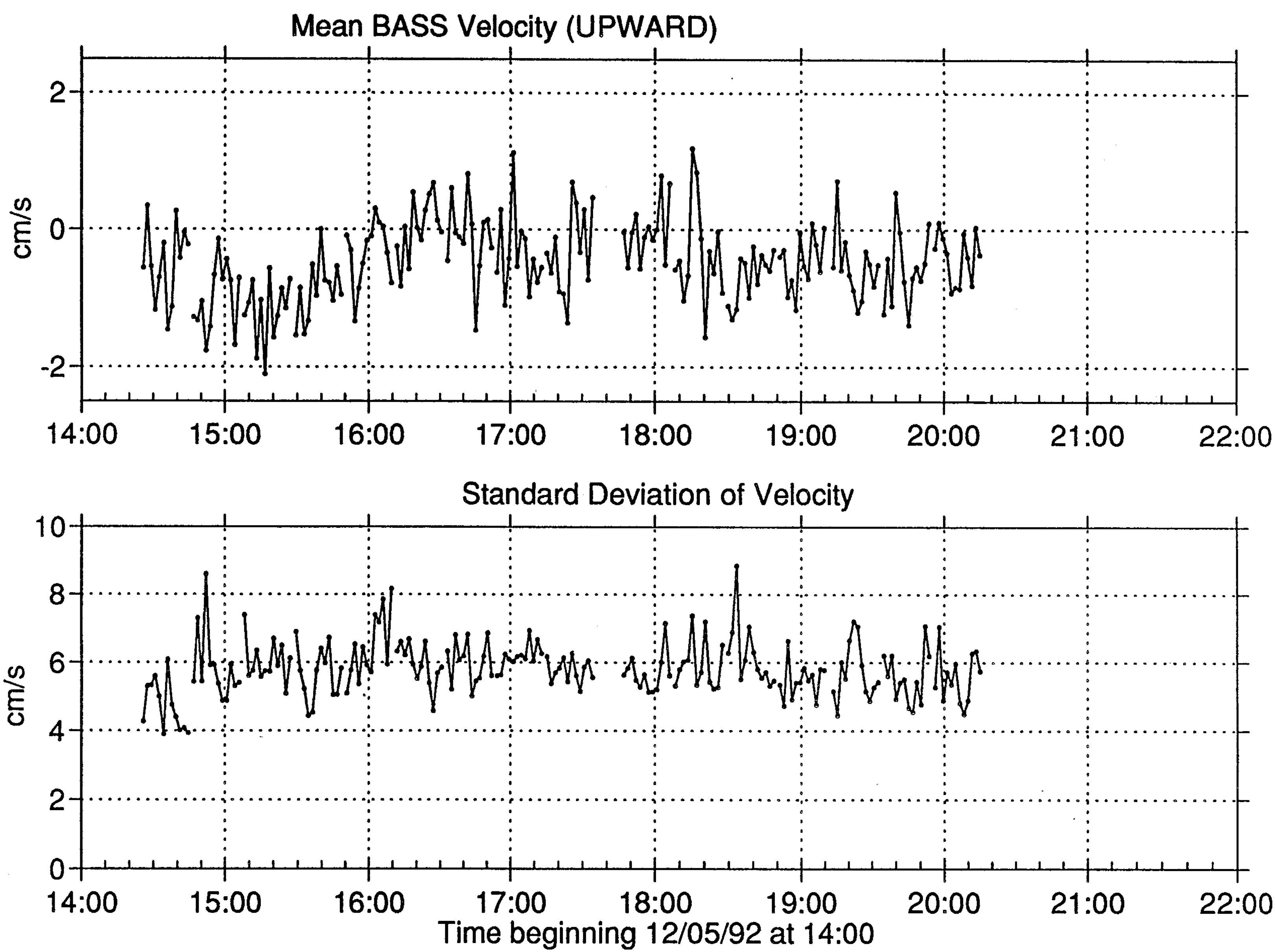

Mean BASS Velocity (UPWARD)
cm/s
2
0
-2
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
Standard Deviation of Velocity
cm/s
10
8
6
4
2
0
Time beginning 12/05/92 at 14:00

Figure 75.

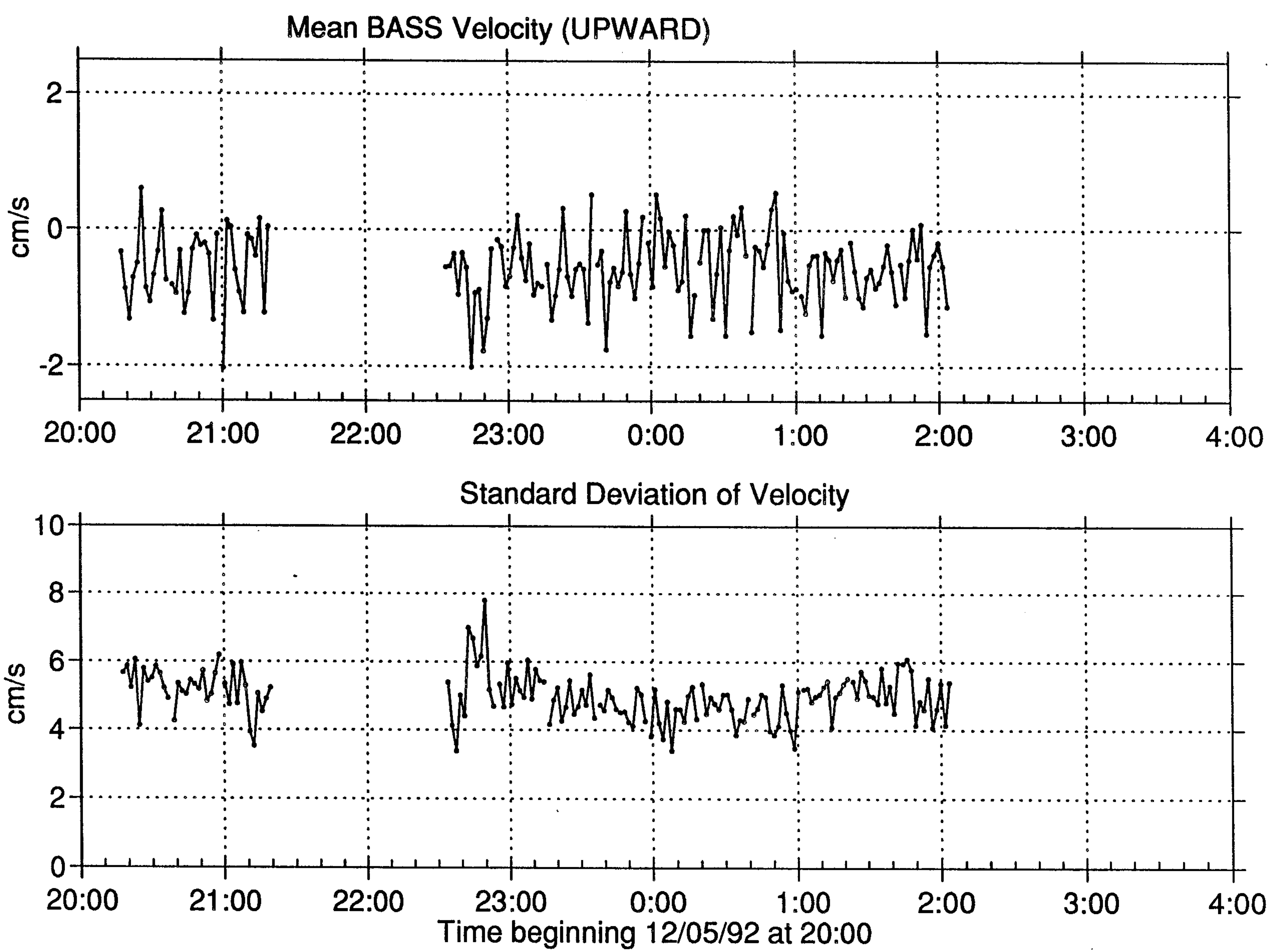

Mean BASS Velocity (UPWARD)
cm/s
2
0
-2
20:00
21:00
22:00
23:00
0:00
1:00
2:00
3:00
4:00
Standard Deviation of Velocity
cm/s
10
8
6
4
2
0
20:00
21:00
22:00
23:00
0:00
1:00
2:00
3:00
4:00
Time beginning 12/05/92 at 20:00

Figure 76.

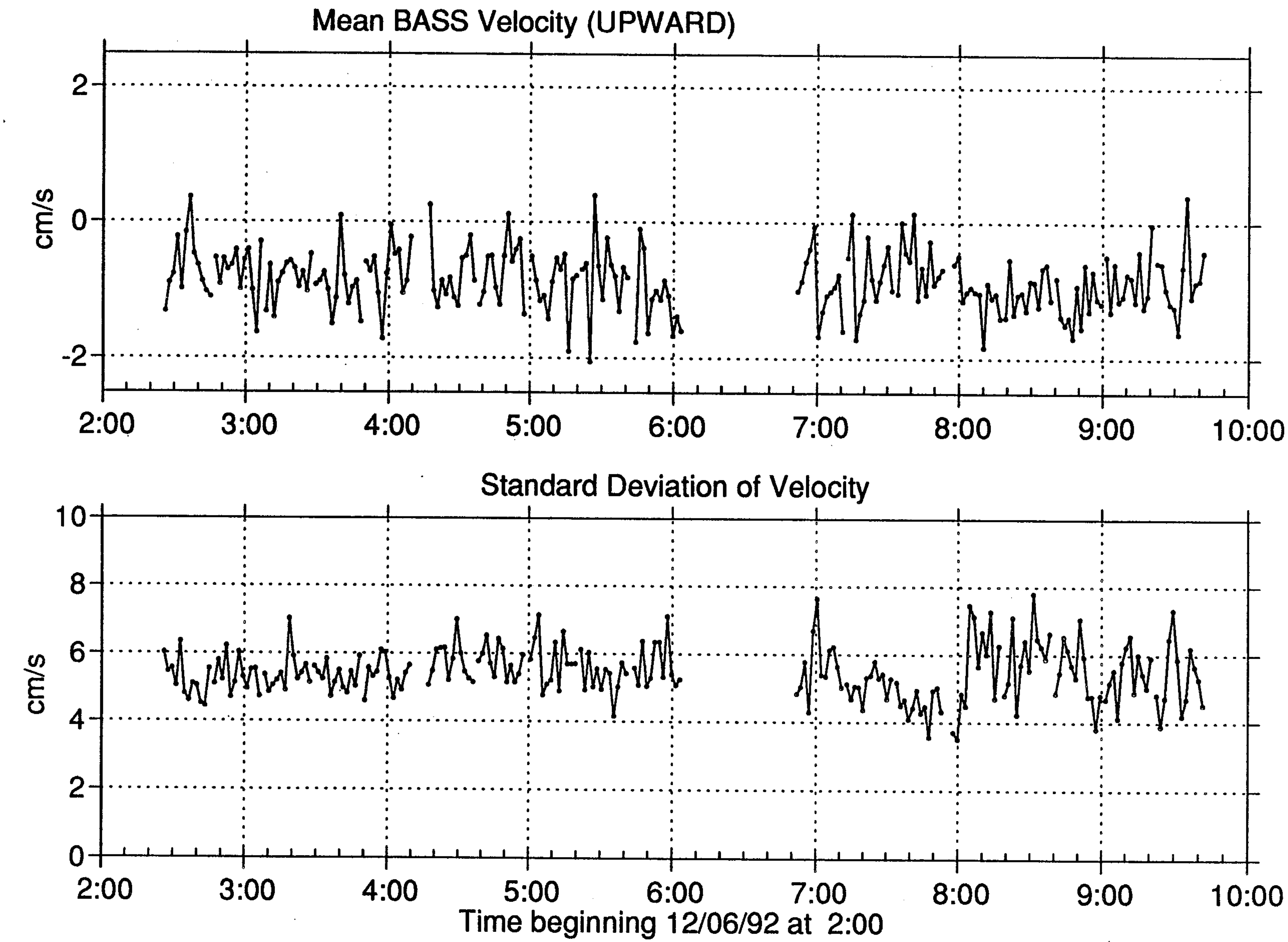

Mean BASS Velocity (UPWARD)
cm/s
2
0
-2
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
Standard Deviation of Velocity
cm/s
10
8
6
4
2
0
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
Time beginning 12/06/92 at 2:00

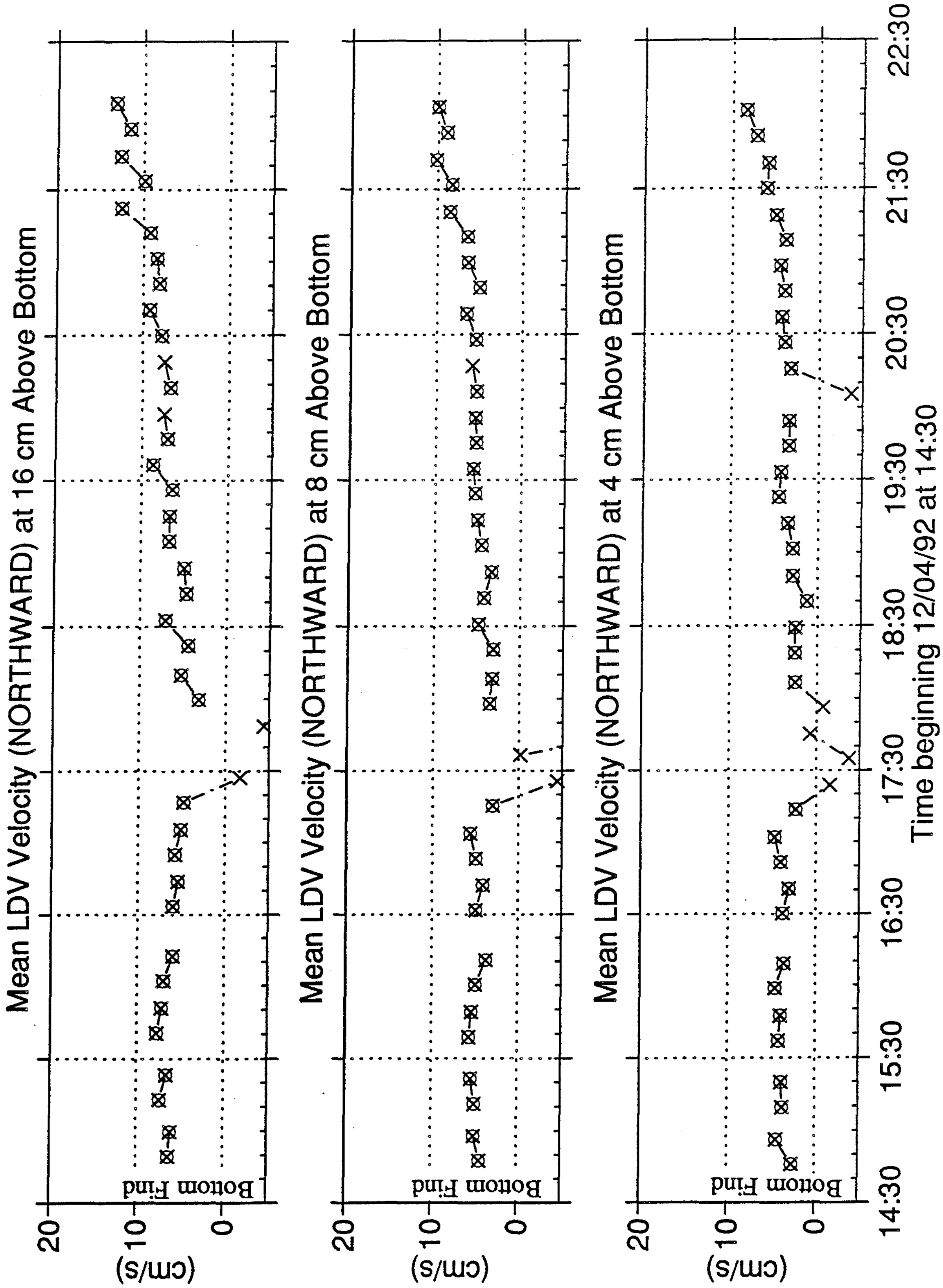
Figure 77.

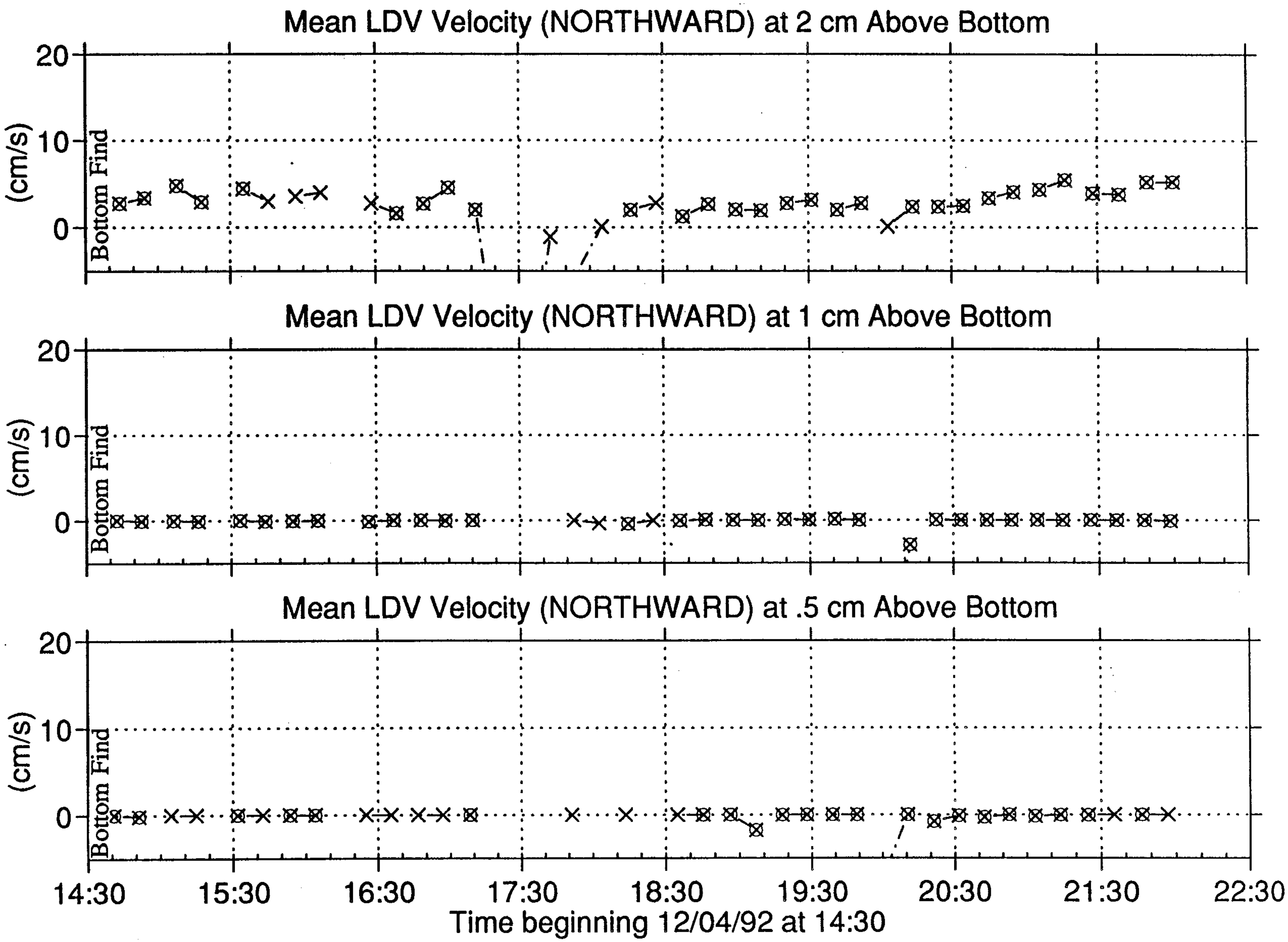
6.3 LDV VELOCITY DATA

The LDV velocity data are presented in this section. Heights above bottom, as noted on plots, are referenced to bottom elevations located by the bottom-find operation. See Table 1 (Section 3) for details.

The records which include over 8% data return (valid data) are highlighted by overlaying a circle on the observation.

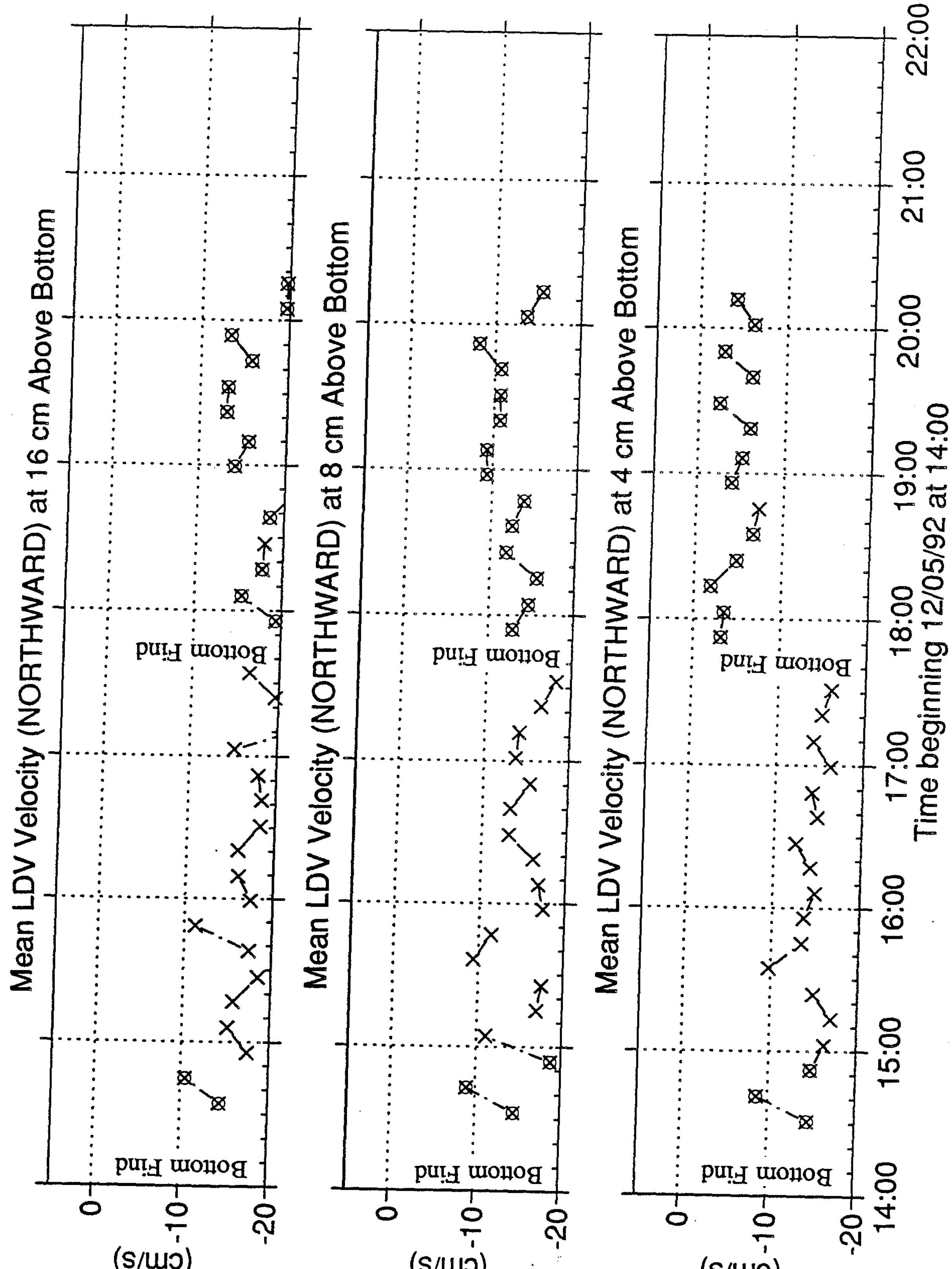
As explained in Section 4, EW-LDV could be processed for very few observations. These processed data are presented here.

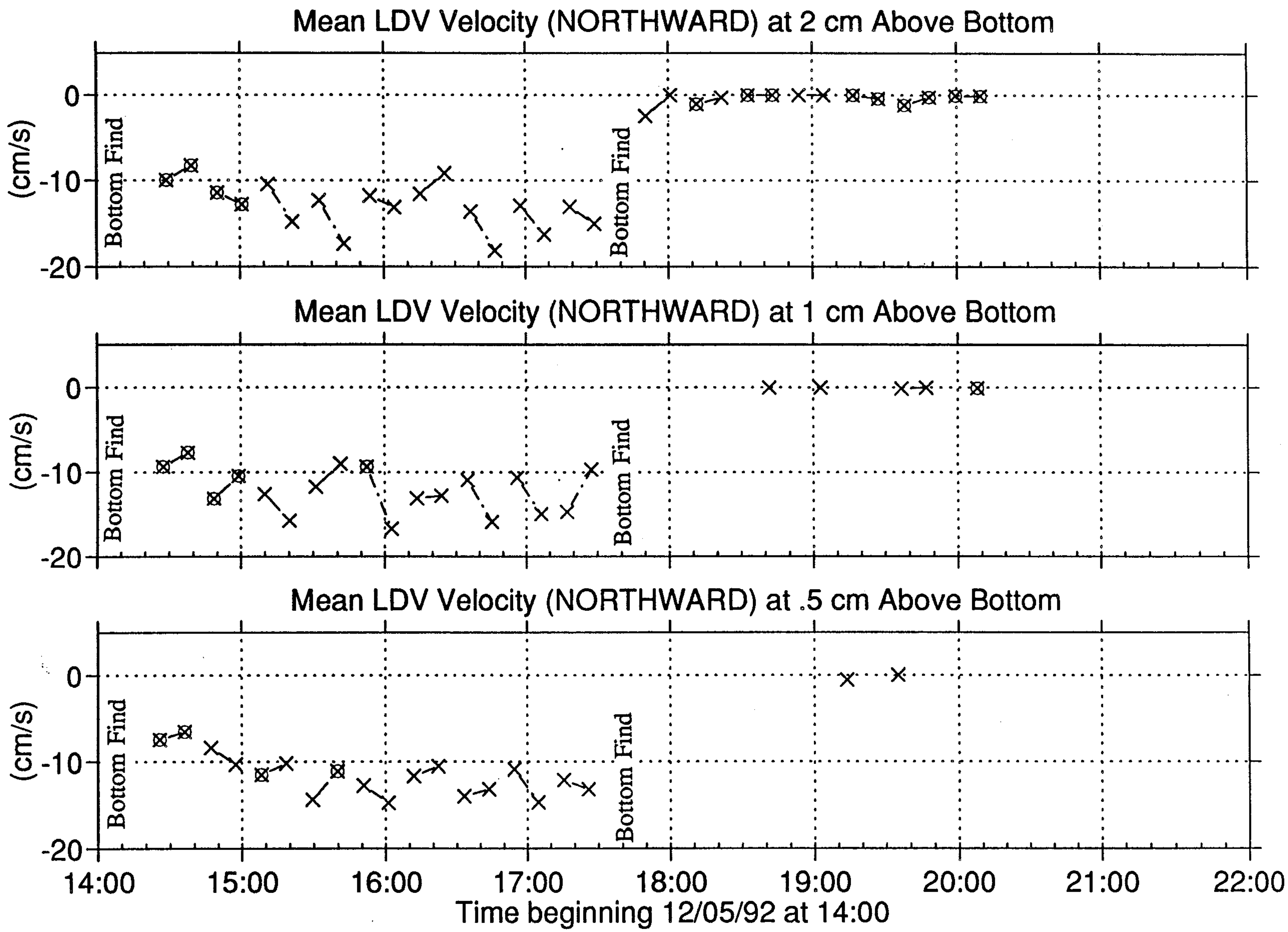

Mean LDV Velocity (NORTHWARD) at 16 cm Above Bottom
Mean LDV Velocity (NORTHWARD) at 8 cm Above Bottom
Mean LDV Velocity (NORTHWARD) at 4 cm Above Bottom
(cm/s)
20
10
0
Bottom Find
14:30
15:30
16:30
17:30
18:30
19:30
20:30
21:30
22:30
Time beginning 12/04/92 at 14:30



Mean LDV Velocity (NORTHWARD) at 2 cm Above Bottom
20
10
0
(cm/s)
Bottom Find
Mean LDV Velocity (NORTHWARD) at 1 cm Above Bottom
20
10
0
(cm/s)
Bottom Find
Mean LDV Velocity (NORTHWARD) at .5 cm Above Bottom
20
10
0
(cm/s)
Bottom Find
14:30
15:30
16:30
17:30
18:30
19:30
20:30
21:30
22:30
Time beginning 12/04/92 at 14:30

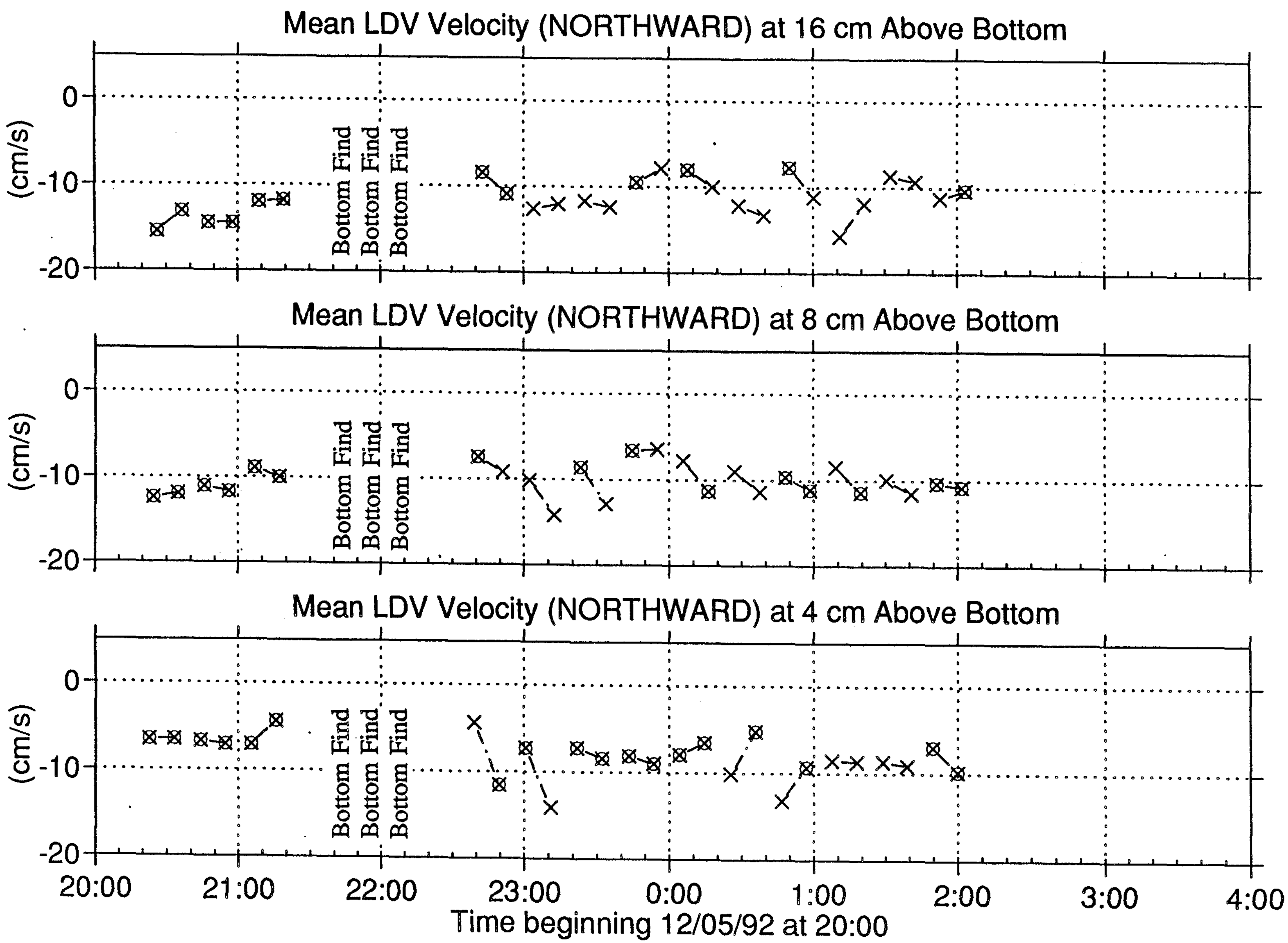
Figure 78.

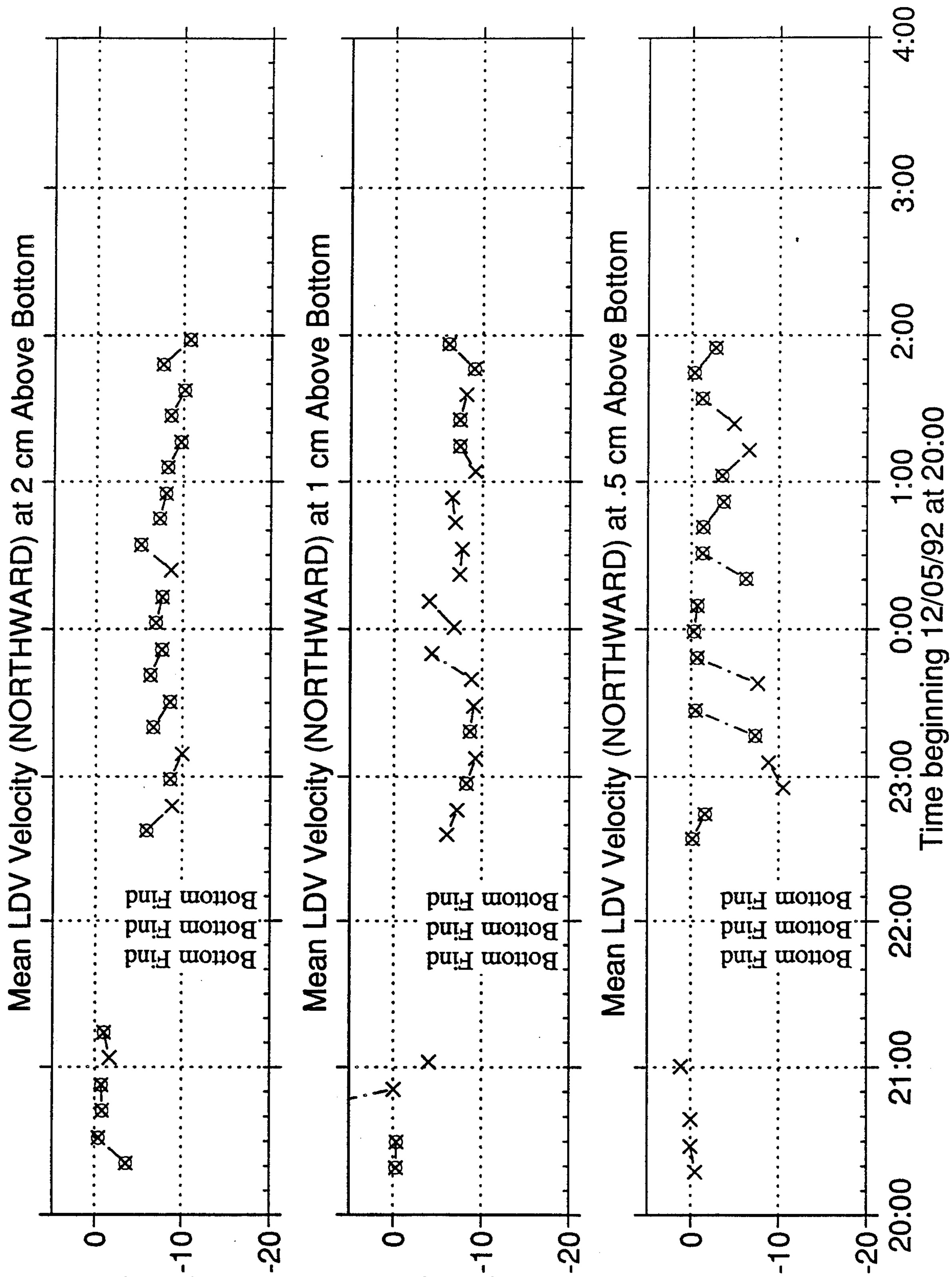

Mean LDV Velocity (NORTHWARD) at 16 cm Above Bottom
Mean LDV Velocity (NORTHWARD) at 8 cm Above Bottom
Mean LDV Velocity (NORTHWARD) at 4 cm Above Bottom
(cm/s)
0
-10
-20
Bottom Find
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
Time beginning 12/05/92 at 14:00



Mean LDV Velocity (NORTHWARD) at 2 cm Above Bottom
Mean LDV Velocity (NORTHWARD) at 1 cm Above Bottom
Mean LDV Velocity (NORTHWARD) at .5 cm Above Bottom
(cm/s)
0
-10
-20
Bottom Find
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
Time beginning 12/05/92 at 14:00

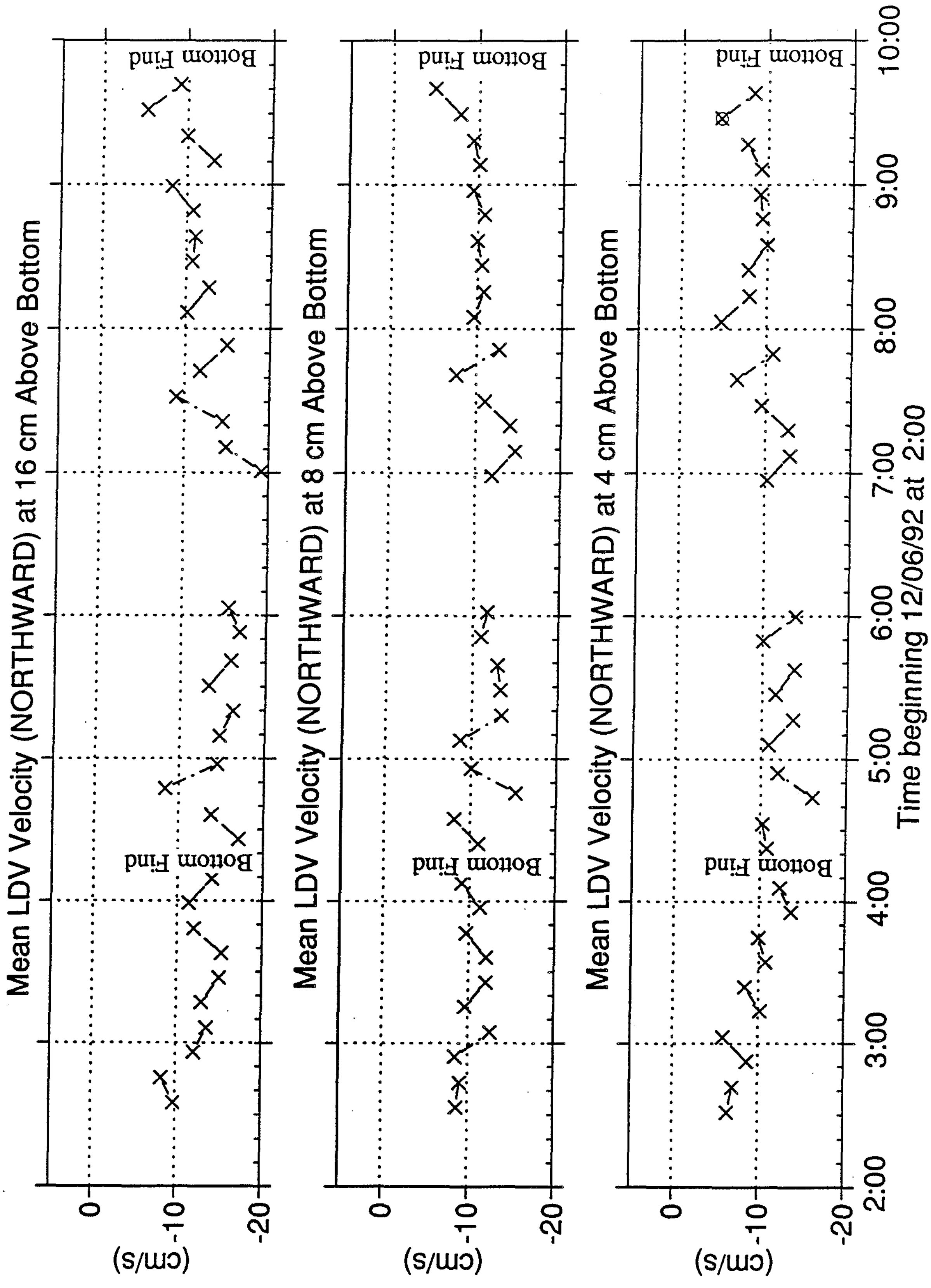
Figure 79.


Mean LDV Velocity (NORTHWARD) at 16 cm Above Bottom
Mean LDV Velocity (NORTHWARD) at 8 cm Above Bottom
Mean LDV Velocity (NORTHWARD) at 4 cm Above Bottom
(cm/s)
0
-10
-20
Bottom Find
20:00
21:00
22:00
23:00
0:00
1:00
2:00
3:00
4:00
Time beginning 12/05/92 at 20:00

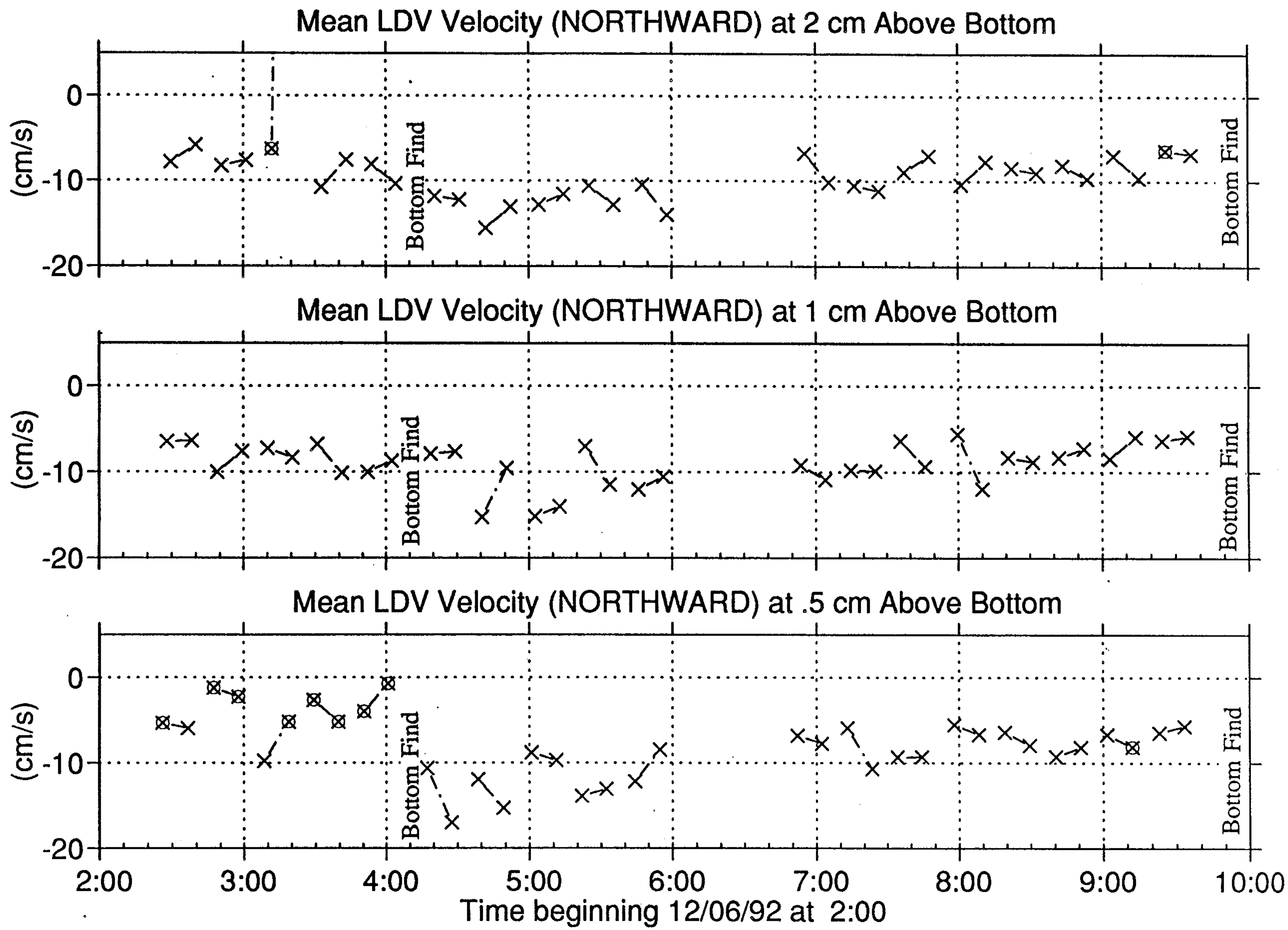


Mean LDV Velocity (NORTHWARD) at 2 cm Above Bottom
Mean LDV Velocity (NORTHWARD) at 1 cm Above Bottom
Mean LDV Velocity (NORTHWARD) at .5 cm Above Bottom
(cm/s)
0
-10
-20
Bottom Find
Bottom Find
Bottom Find
20:00
21:00
22:00
23:00
0:00
1:00
2:00
3:00
4:00
Time beginning 12/05/92 at 20:00

Figure 80.

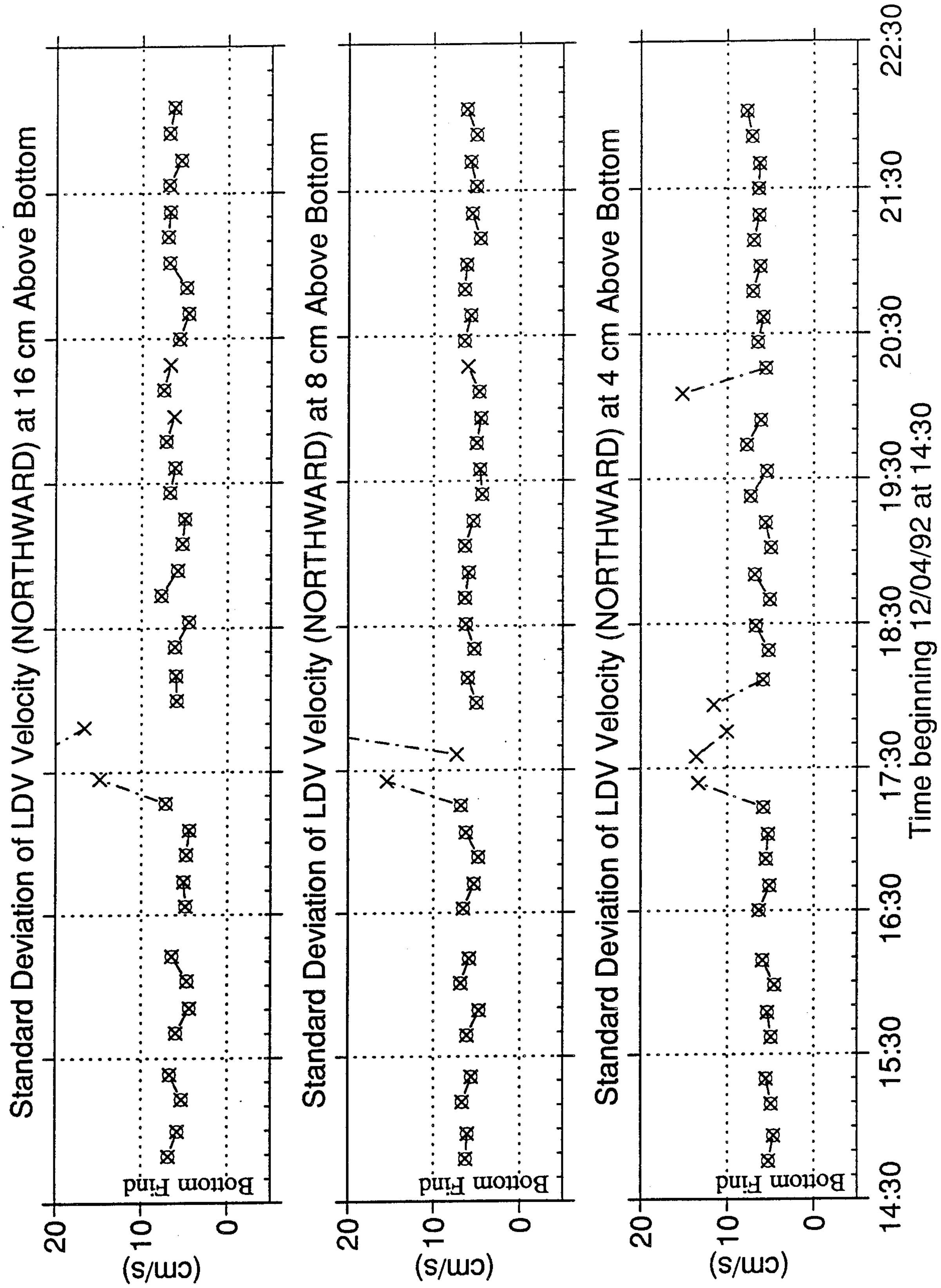


Mean LDV Velocity (NORTHWARD) at 16 cm Above Bottom
Mean LDV Velocity (NORTHWARD) at 8 cm Above Bottom
Mean LDV Velocity (NORTHWARD) at 4 cm Above Bottom
Bottom Find
(cm/s)
0
-10
-20
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
Time beginning 12/06/92 at 2:00



Mean LDV Velocity (NORTHWARD) at 2 cm Above Bottom
(cm/s)
0
-10
-20
Bottom Find
Bottom Find
Mean LDV Velocity (NORTHWARD) at 1 cm Above Bottom
(cm/s)
0
-10
-20
Bottom Find
Bottom Find
Mean LDV Velocity (NORTHWARD) at .5 cm Above Bottom
(cm/s)
0
-10
-20
Bottom Find
Bottom Find
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
Time beginning 12/06/92 at 2:00

Figure 81.


Standard Deviation of LDV Velocity (NORTHWARD) at 16 cm Above Bottom
Standard Deviation of LDV Velocity (NORTHWARD) at 8 cm Above Bottom
Standard Deviation of LDV Velocity (NORTHWARD) at 4 cm Above Bottom
(cm/s)
20
10
0
Bottom Find
14:30
15:30
16:30
17:30
18:30
19:30
20:30
21:30
22:30
Time beginning 12/04/92 at 14:30

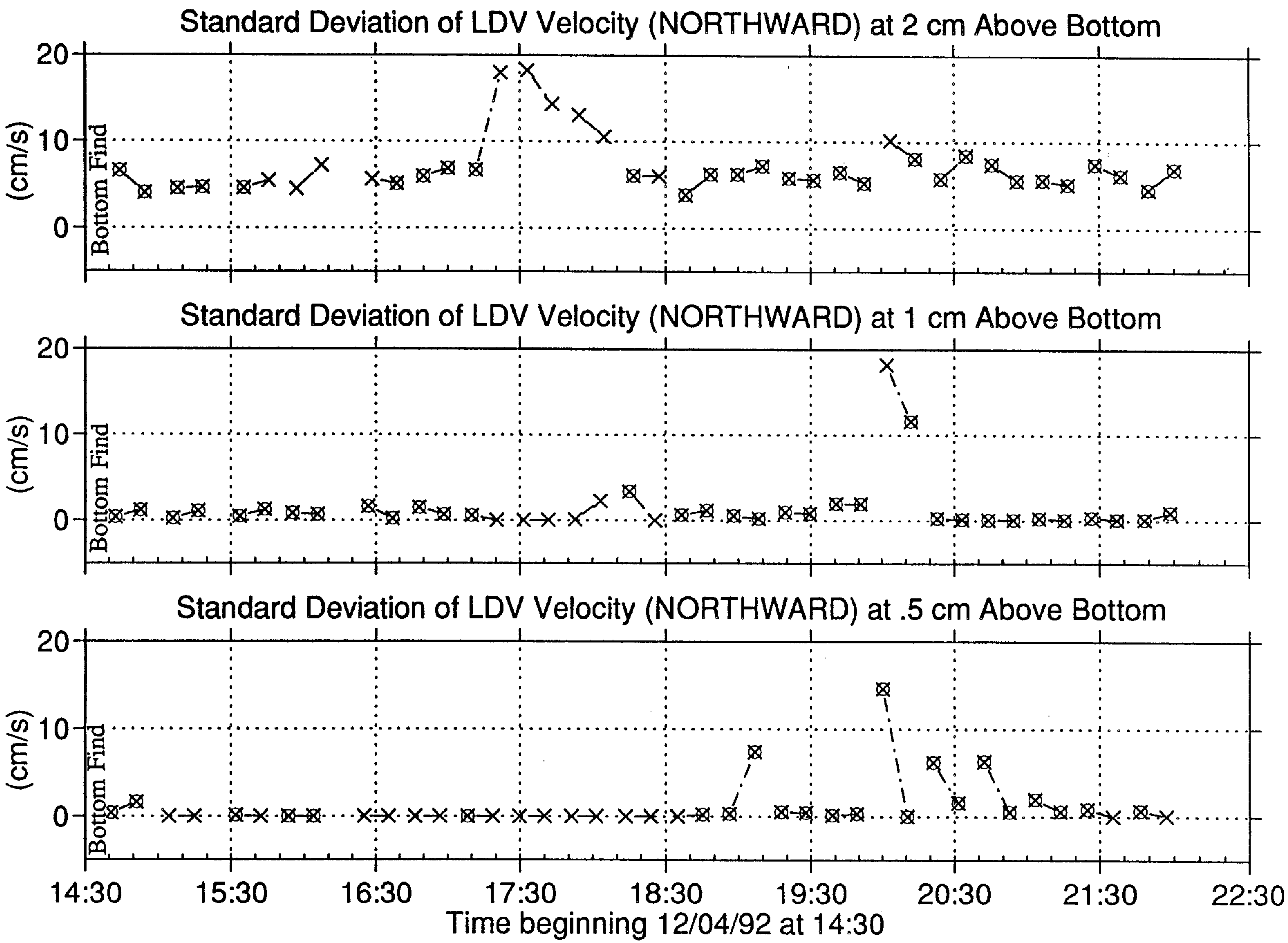
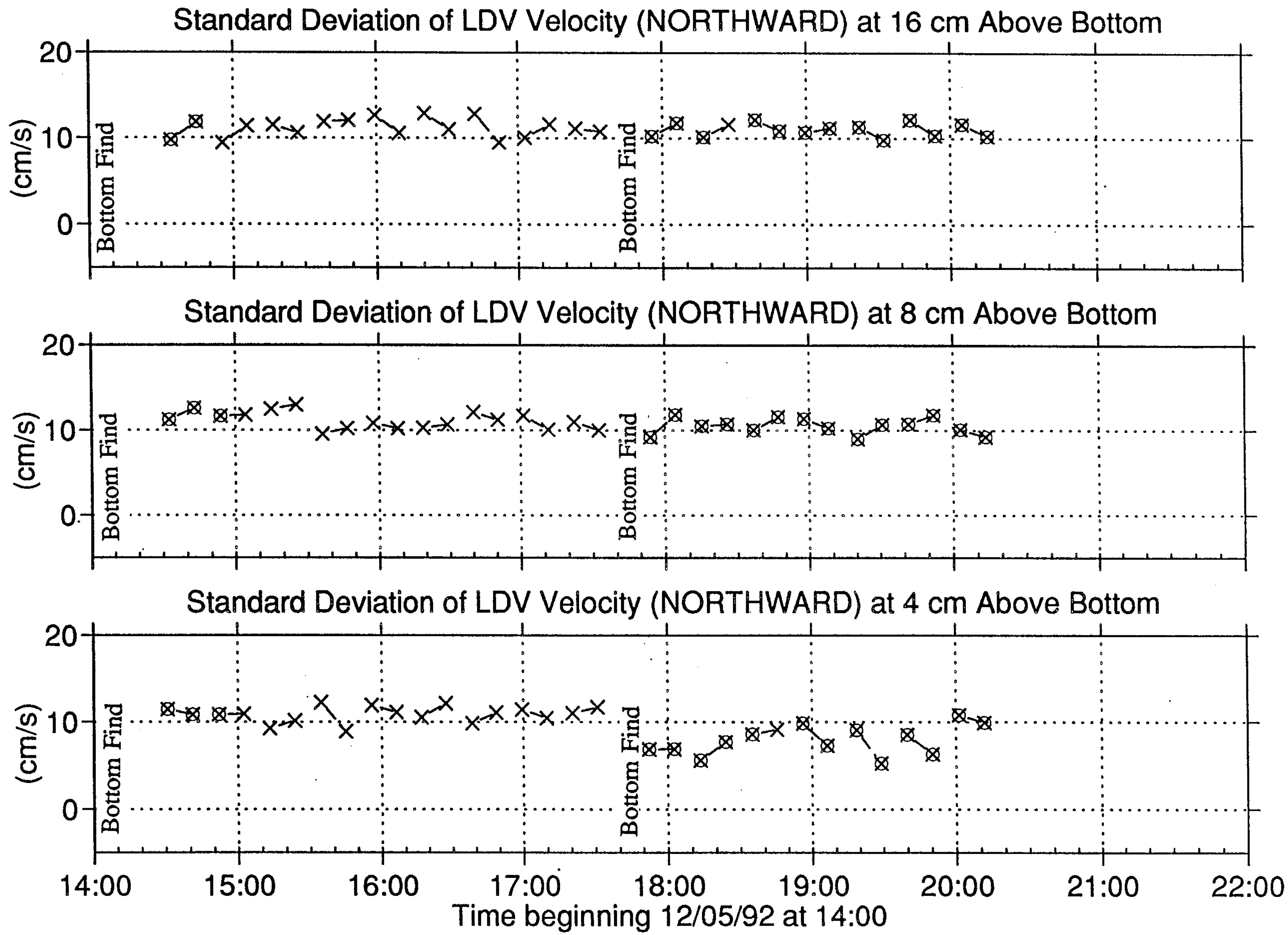

Standard Deviation of LDV Velocity (NORTHWARD) at 2 cm Above Bottom
(cm/s)
20
10
0
Bottom Find
Standard Deviation of LDV Velocity (NORTHWARD) at 1 cm Above Bottom
(cm/s)
20
10
0
Bottom Find
Standard Deviation of LDV Velocity (NORTHWARD) at .5 cm Above Bottom
(cm/s)
20
10
0
Bottom Find
14:30
15:30
16:30
17:30
18:30
19:30
20:30
21:30
22:30
Time beginning 12/04/92 at 14:30

Figure 82.


Standard Deviation of LDV Velocity (NORTHWARD) at 16 cm Above Bottom
Standard Deviation of LDV Velocity (NORTHWARD) at 8 cm Above Bottom
Standard Deviation of LDV Velocity (NORTHWARD) at 4 cm Above Bottom
(cm/s)
20
10
0
Bottom Find
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
Time beginning 12/05/92 at 14:00

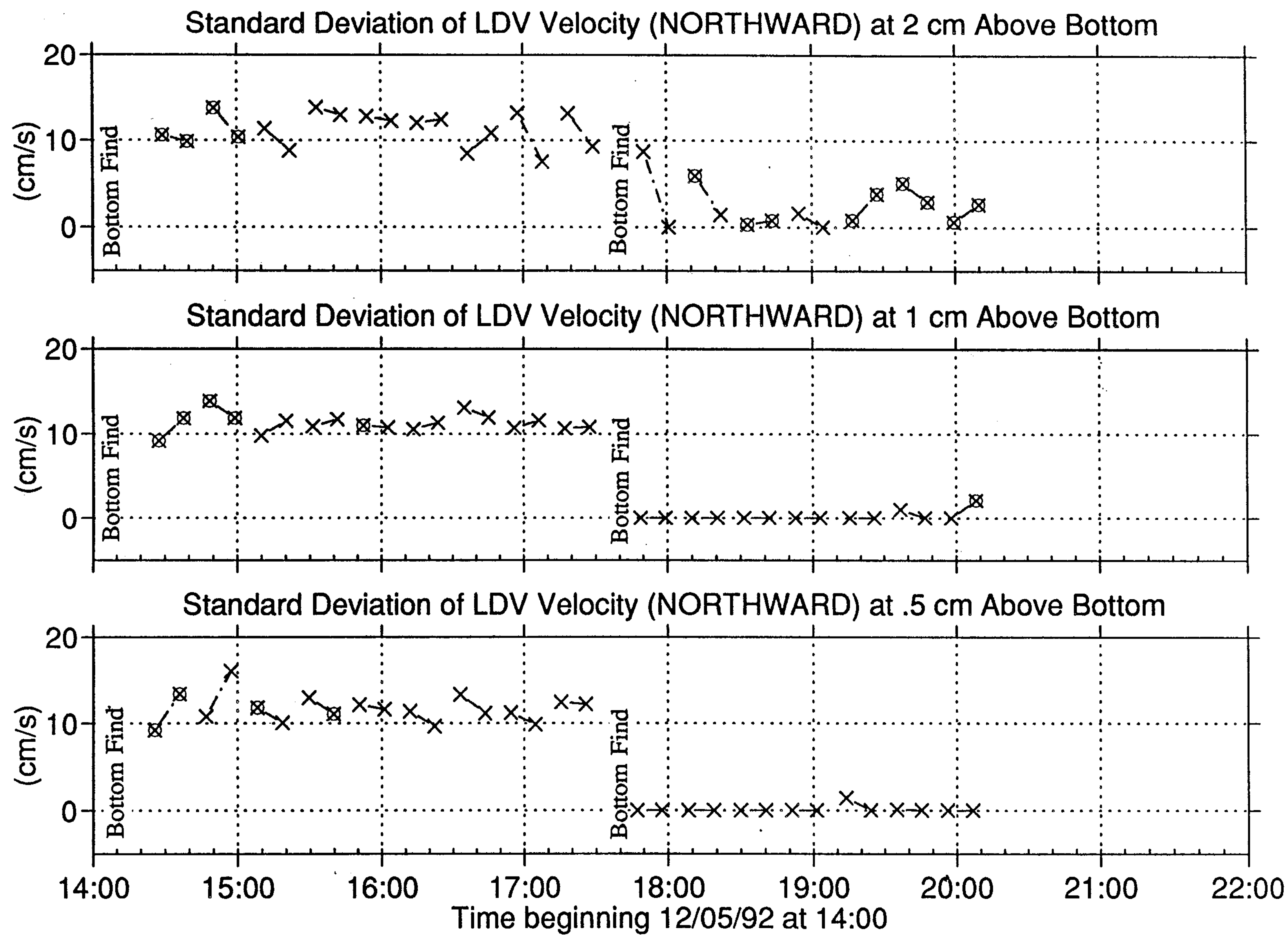
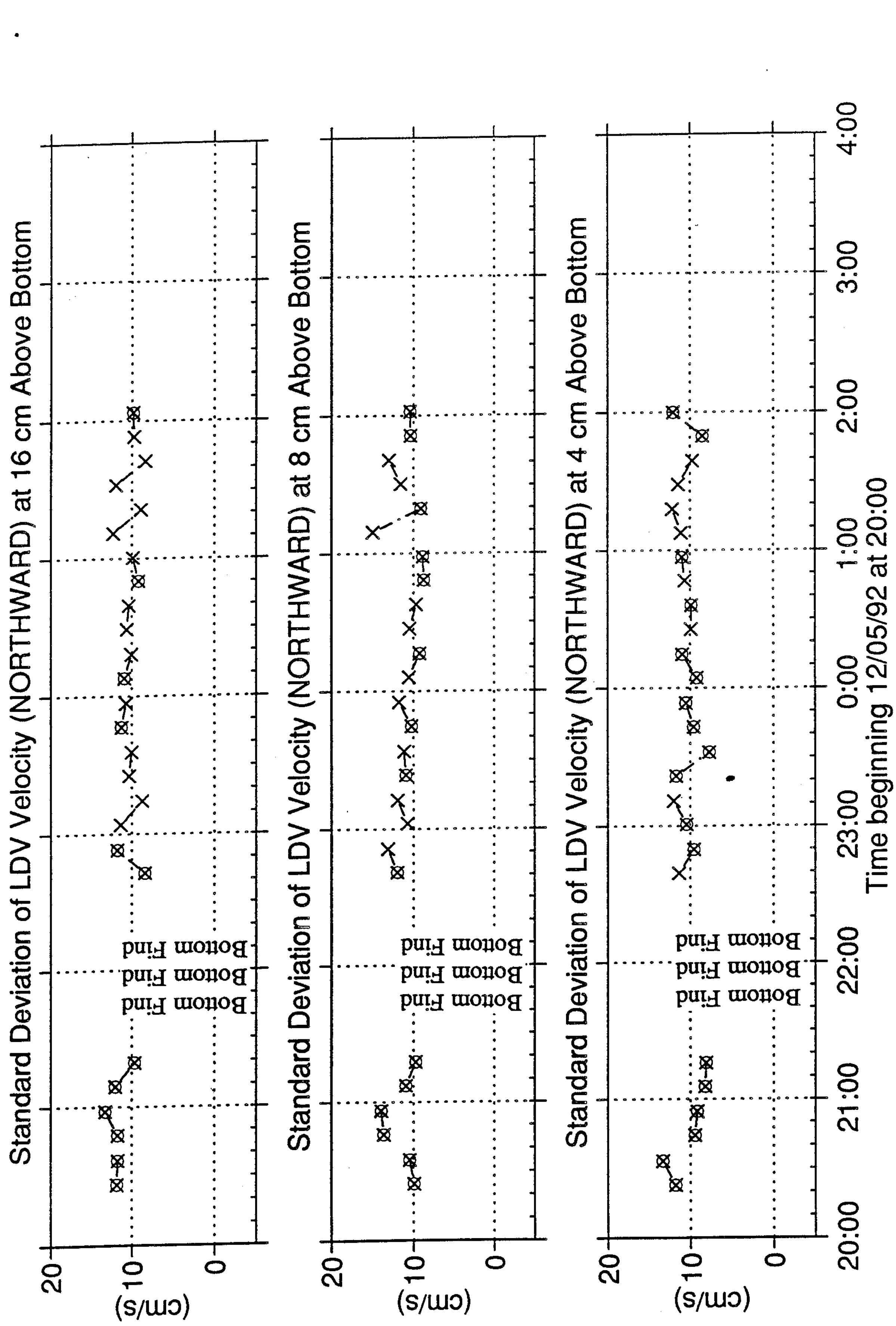

Standard Deviation of LDV Velocity (NORTHWARD) at 2 cm Above Bottom
Standard Deviation of LDV Velocity (NORTHWARD) at 1 cm Above Bottom
Standard Deviation of LDV Velocity (NORTHWARD) at .5 cm Above Bottom
(cm/s)
20
10
0
Bottom Find
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
Time beginning 12/05/92 at 14:00

Figure 83.


Standard Deviation of LDV Velocity (NORTHWARD) at 16 cm Above Bottom
Standard Deviation of LDV Velocity (NORTHWARD) at 8 cm Above Bottom
Standard Deviation of LDV Velocity (NORTHWARD) at 4 cm Above Bottom
(cm/s)
20
10
0
Bottom Find
Bottom Find
Bottom Find
20:00
21:00
22:00
23:00
0:00
1:00
2:00
3:00
4:00
Time beginning 12/05/92 at 20:00

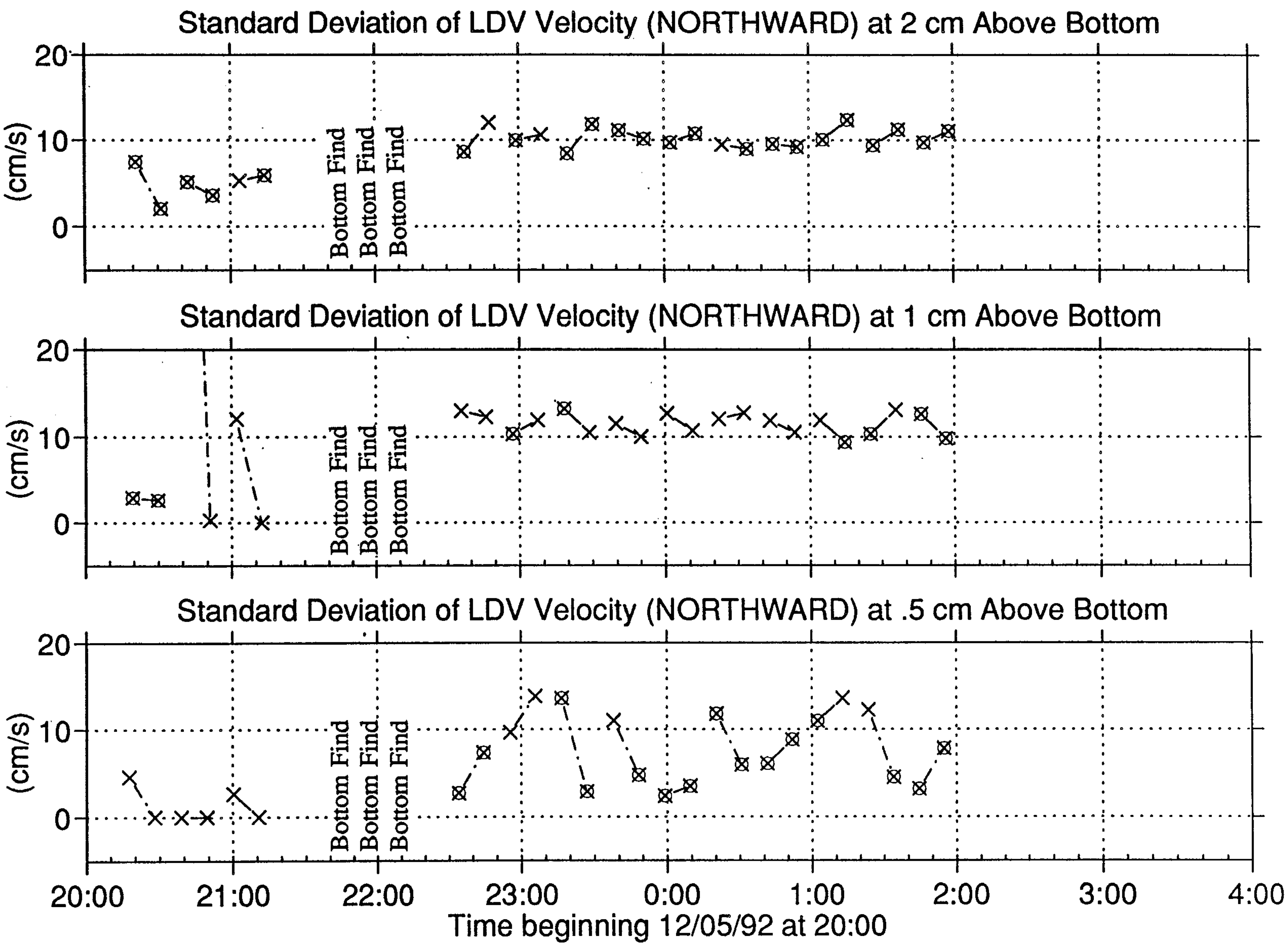
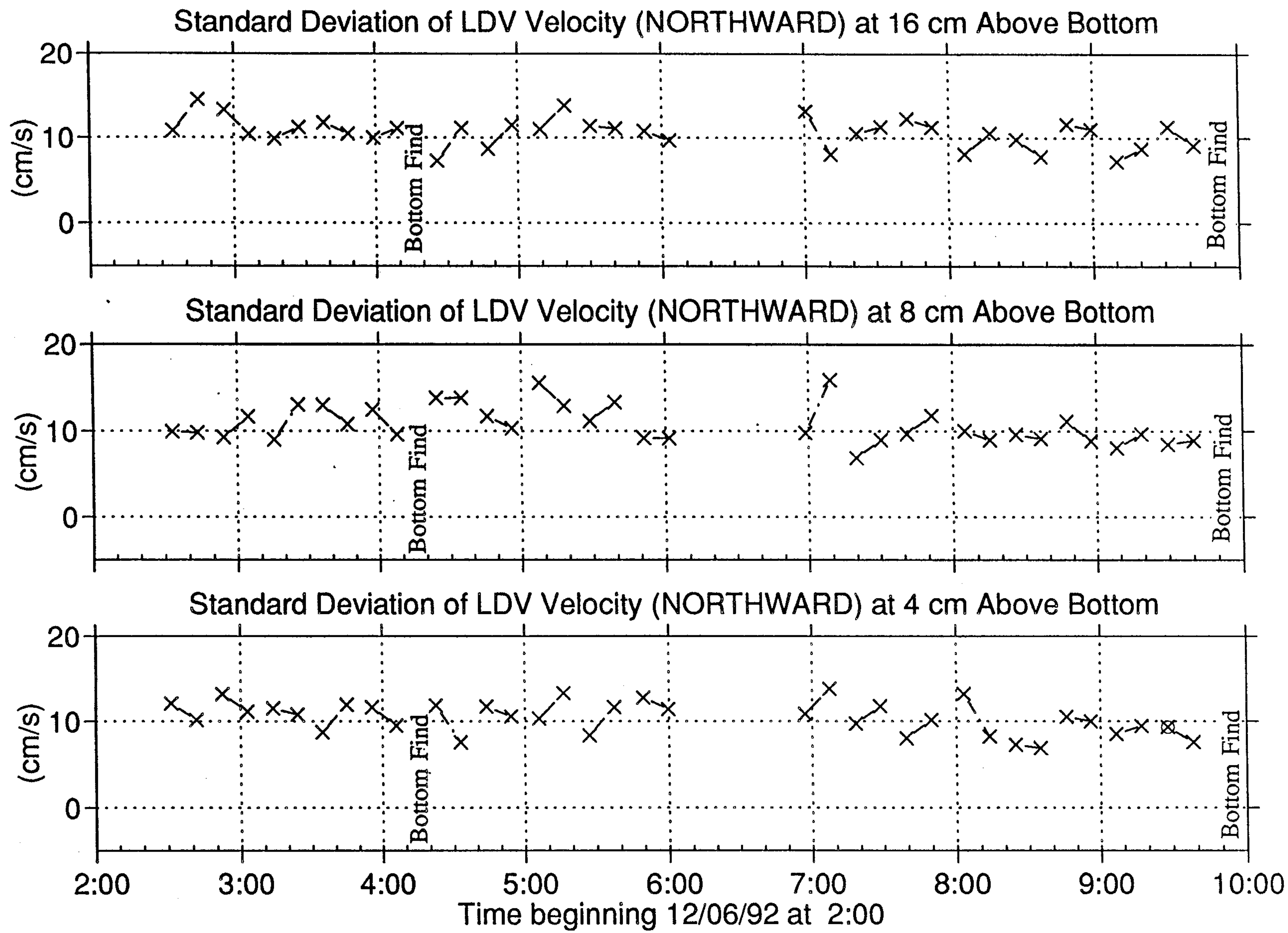
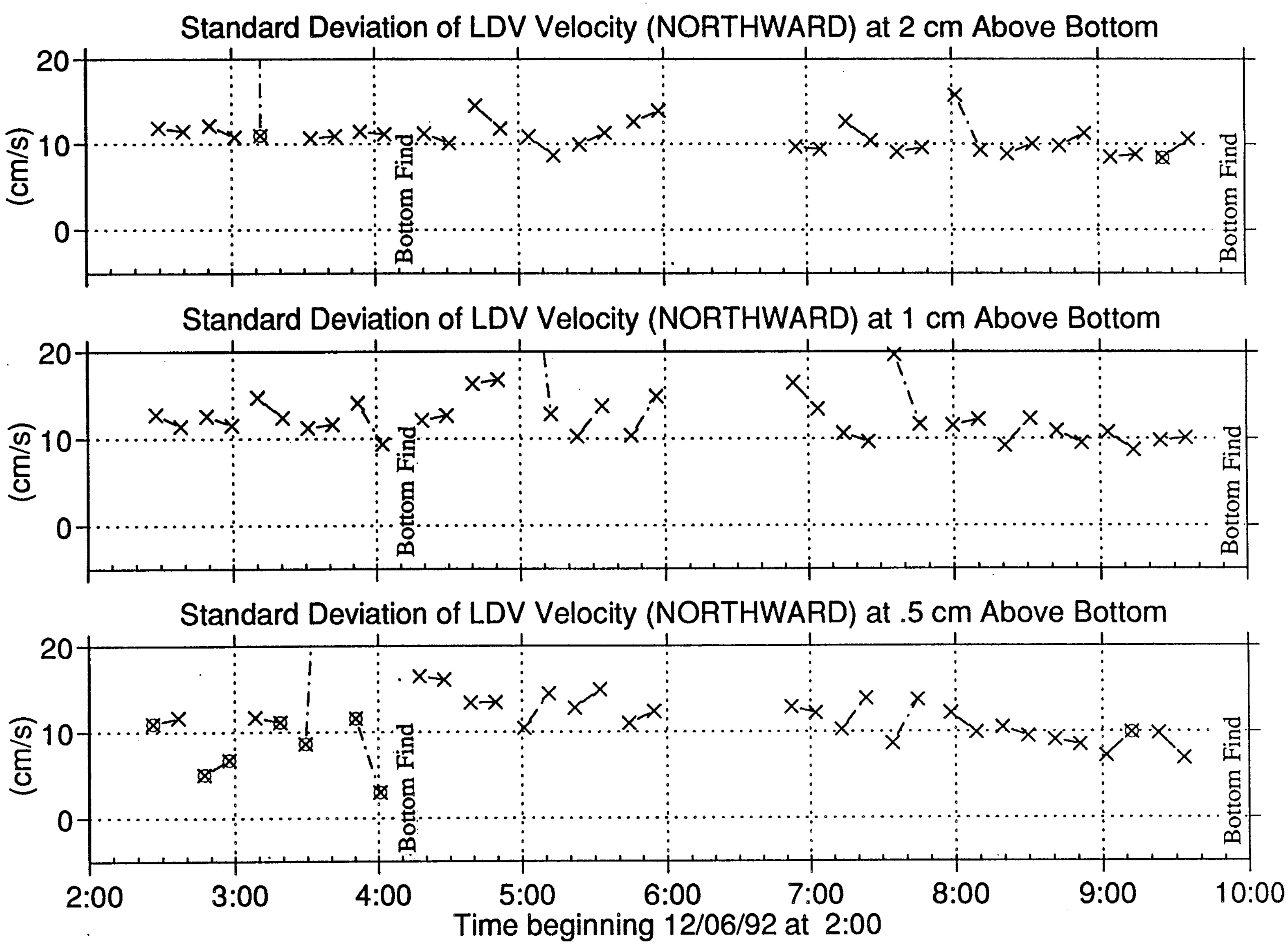

Standard Deviation of LDV Velocity (NORTHWARD) at 2 cm Above Bottom
Standard Deviation of LDV Velocity (NORTHWARD) at 1 cm Above Bottom
Standard Deviation of LDV Velocity (NORTHWARD) at .5 cm Above Bottom
(cm/s)
20
10
0
Bottom Find
Bottom Find
Bottom Find
20:00
21:00
22:00
23:00
0:00
1:00
2:00
3:00
4:00
Time beginning 12/05/92 at 20:00

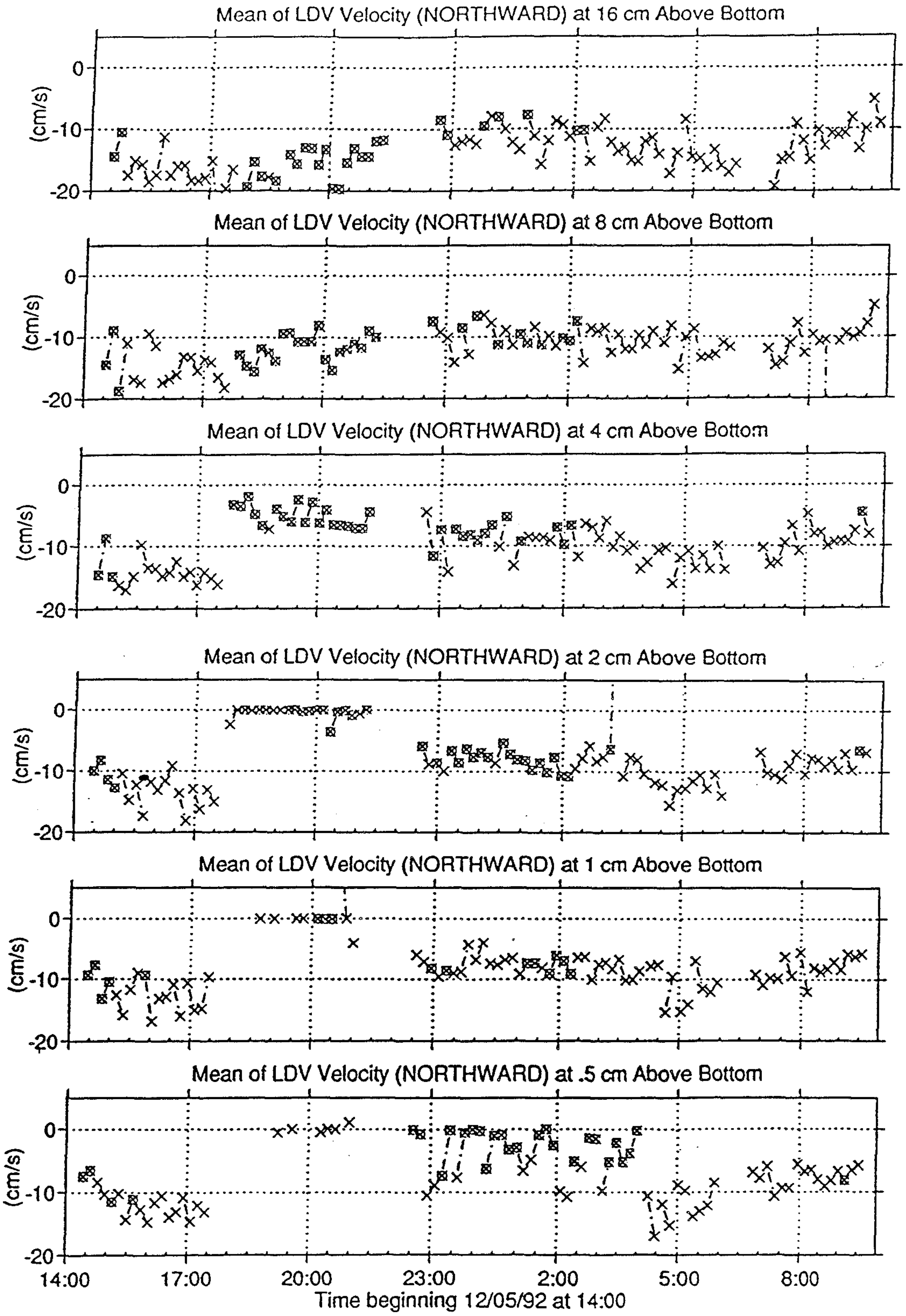
Figure 84.


Standard Deviation of LDV Velocity (NORTHWARD) at 16 cm Above Bottom
(cm/s)
20
10
0
Bottom Find
Bottom Find
Standard Deviation of LDV Velocity (NORTHWARD) at 8 cm Above Bottom
(cm/s)
20
10
0
Bottom Find
Bottom Find
Standard Deviation of LDV Velocity (NORTHWARD) at 4 cm Above Bottom
(cm/s)
20
10
0
Bottom Find
Bottom Find
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
Time beginning 12/06/92 at 2:00



Standard Deviation of LDV Velocity (NORTHWARD) at 2 cm Above Bottom
Standard Deviation of LDV Velocity (NORTHWARD) at 1 cm Above Bottom
Standard Deviation of LDV Velocity (NORTHWARD) at .5 cm Above Bottom
(cm/s)
20
10
0
Bottom Find
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
Time beginning 12/06/92 at 2:00

Figure 85.



Mean of LDV Velocity (NORTHWARD) at 16 cm Above Bottom
Mean of LDV Velocity (NORTHWARD) at 8 cm Above Bottom
Mean of LDV Velocity (NORTHWARD) at 4 cm Above Bottom
Mean of LDV Velocity (NORTHWARD) at 2 cm Above Bottom
Mean of LDV Velocity (NORTHWARD) at 1 cm Above Bottom
Mean of LDV Velocity (NORTHWARD) at .5 cm Above Bottom
(cm/s)
0
-10
-20
14:00
17:00
20:00
23:00
2:00
5:00
8:00
Time beginning 12/05/92 at 14:00

Figure 86.

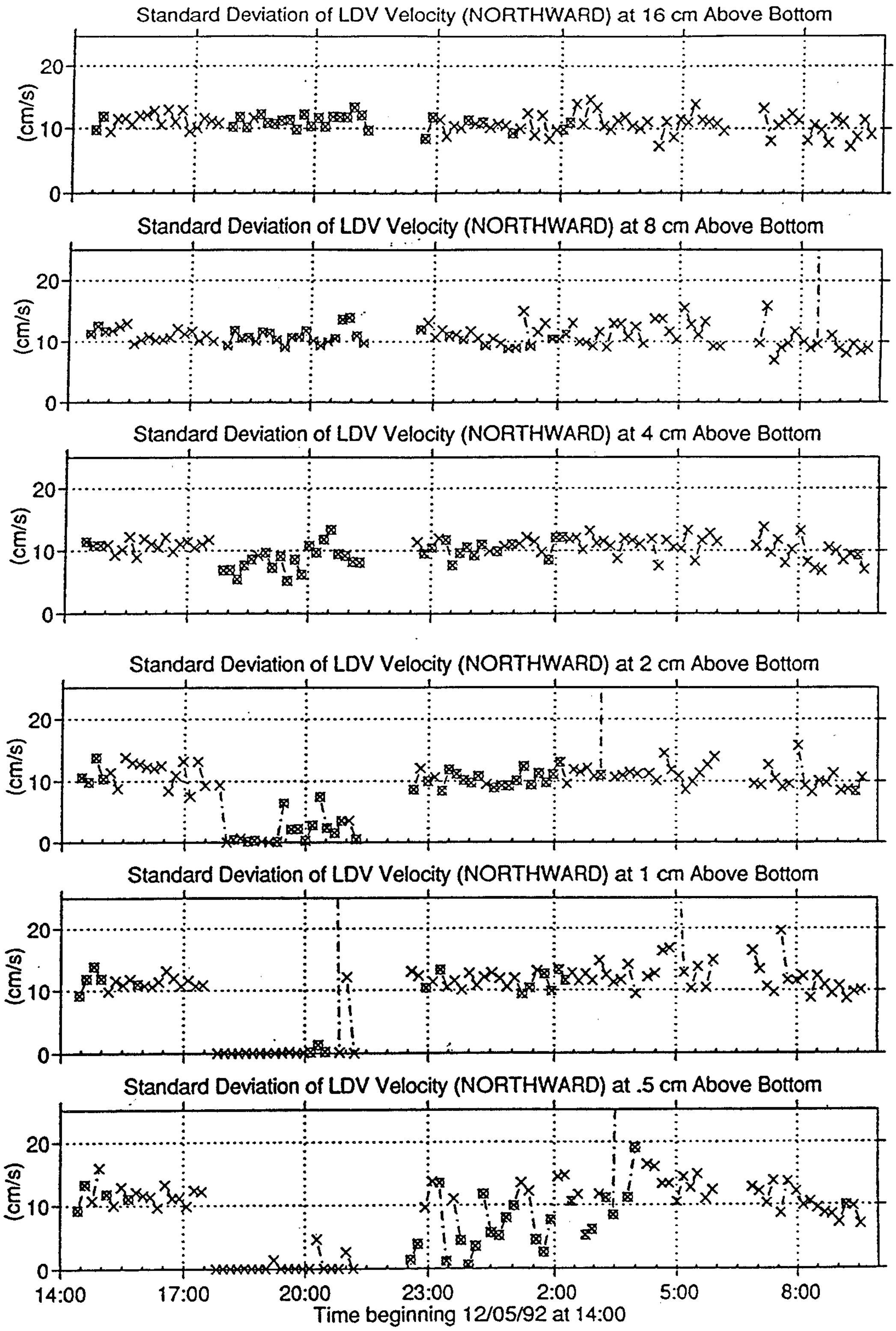
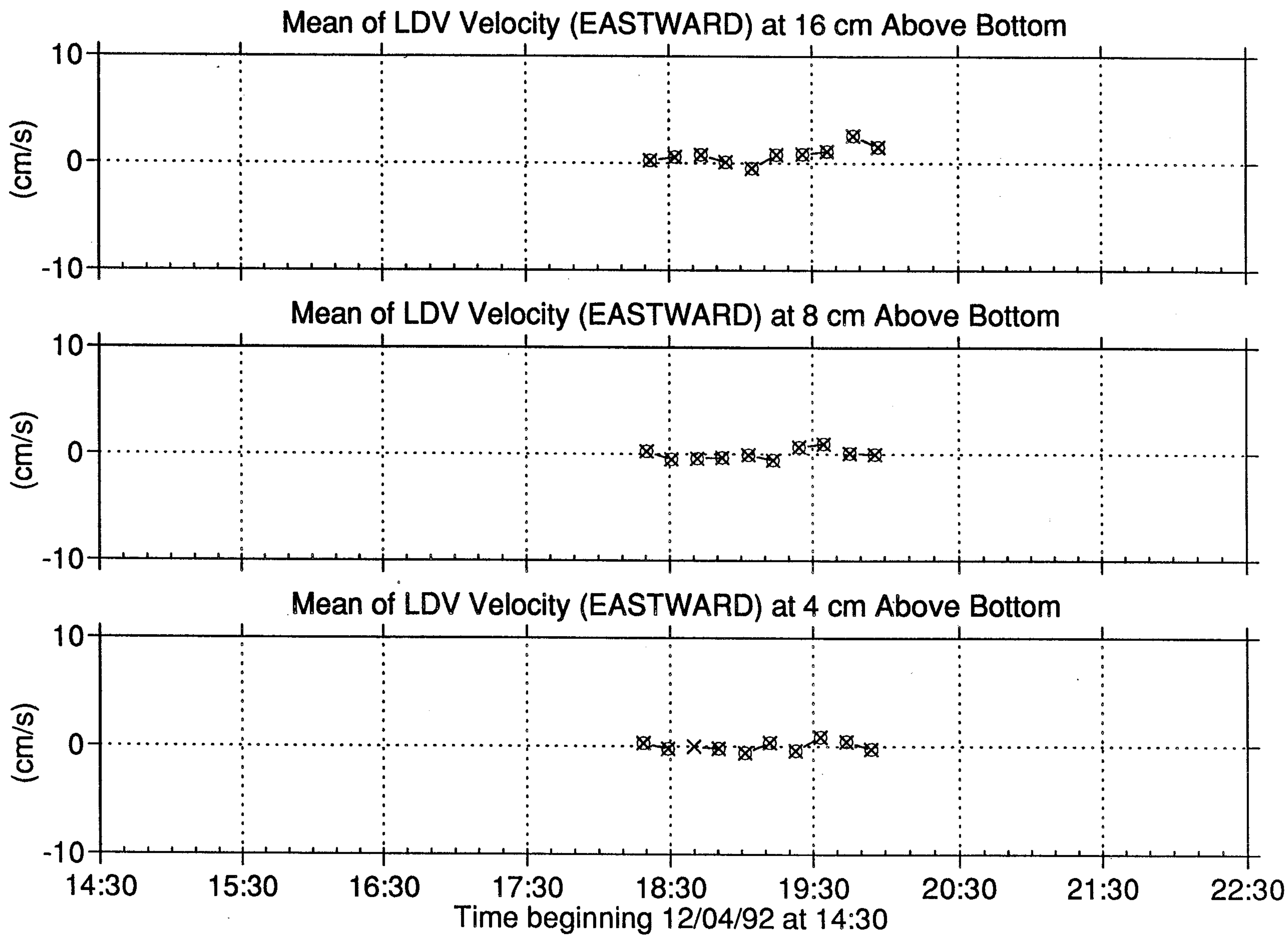
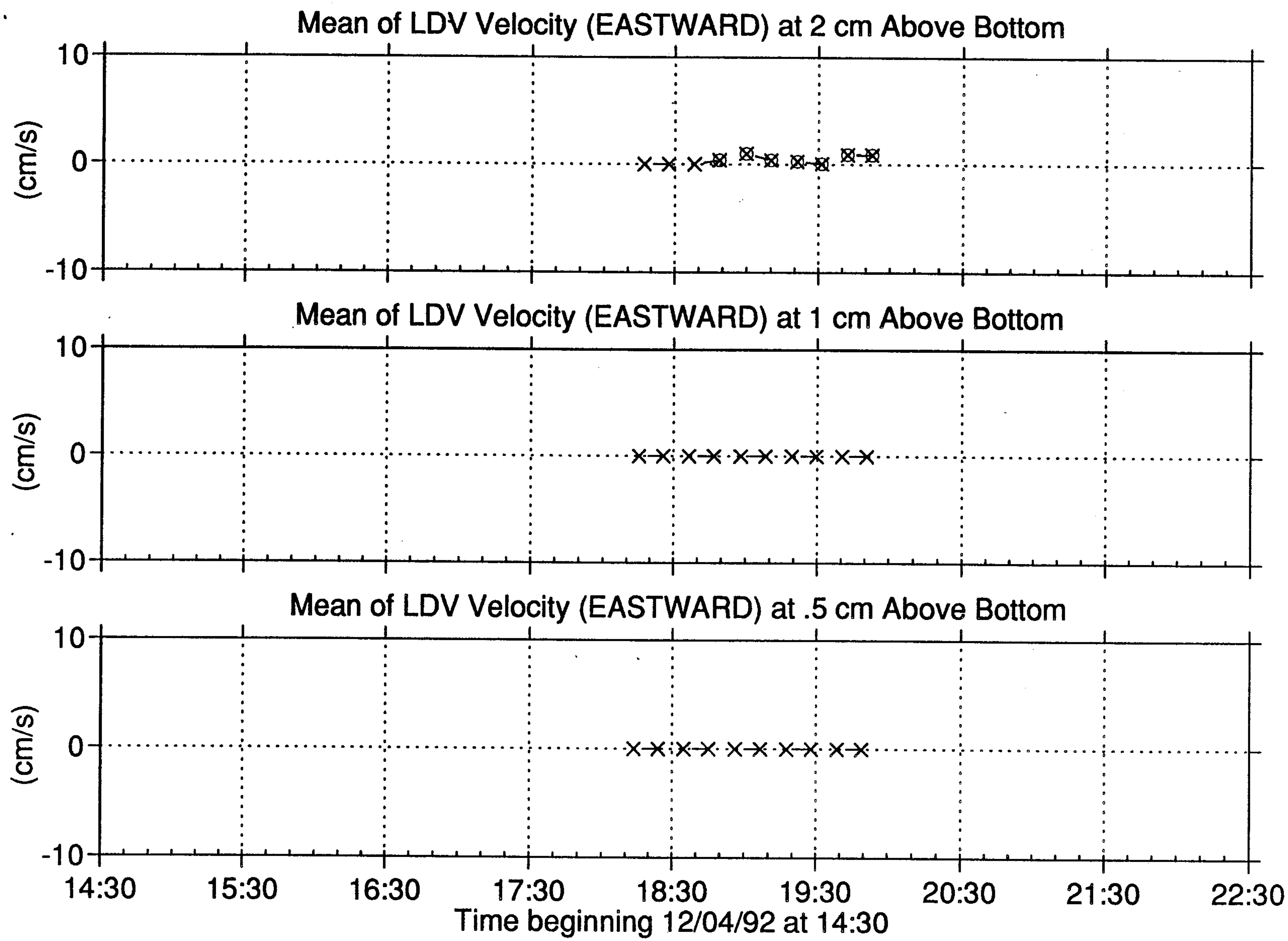

Standard Deviation of LDV Velocity (NORTHWARD) at 16 cm Above Bottom
Standard Deviation of LDV Velocity (NORTHWARD) at 8 cm Above Bottom
Standard Deviation of LDV Velocity (NORTHWARD) at 4 cm Above Bottom
Standard Deviation of LDV Velocity (NORTHWARD) at 2 cm Above Bottom
Standard Deviation of LDV Velocity (NORTHWARD) at 1 cm Above Bottom
Standard Deviation of LDV Velocity (NORTHWARD) at .5 cm Above Bottom
(cm/s)
0
10
20
14:00
17:00
20:00
23:00
2:00
5:00
8:00
Time beginning 12/05/92 at 14:00

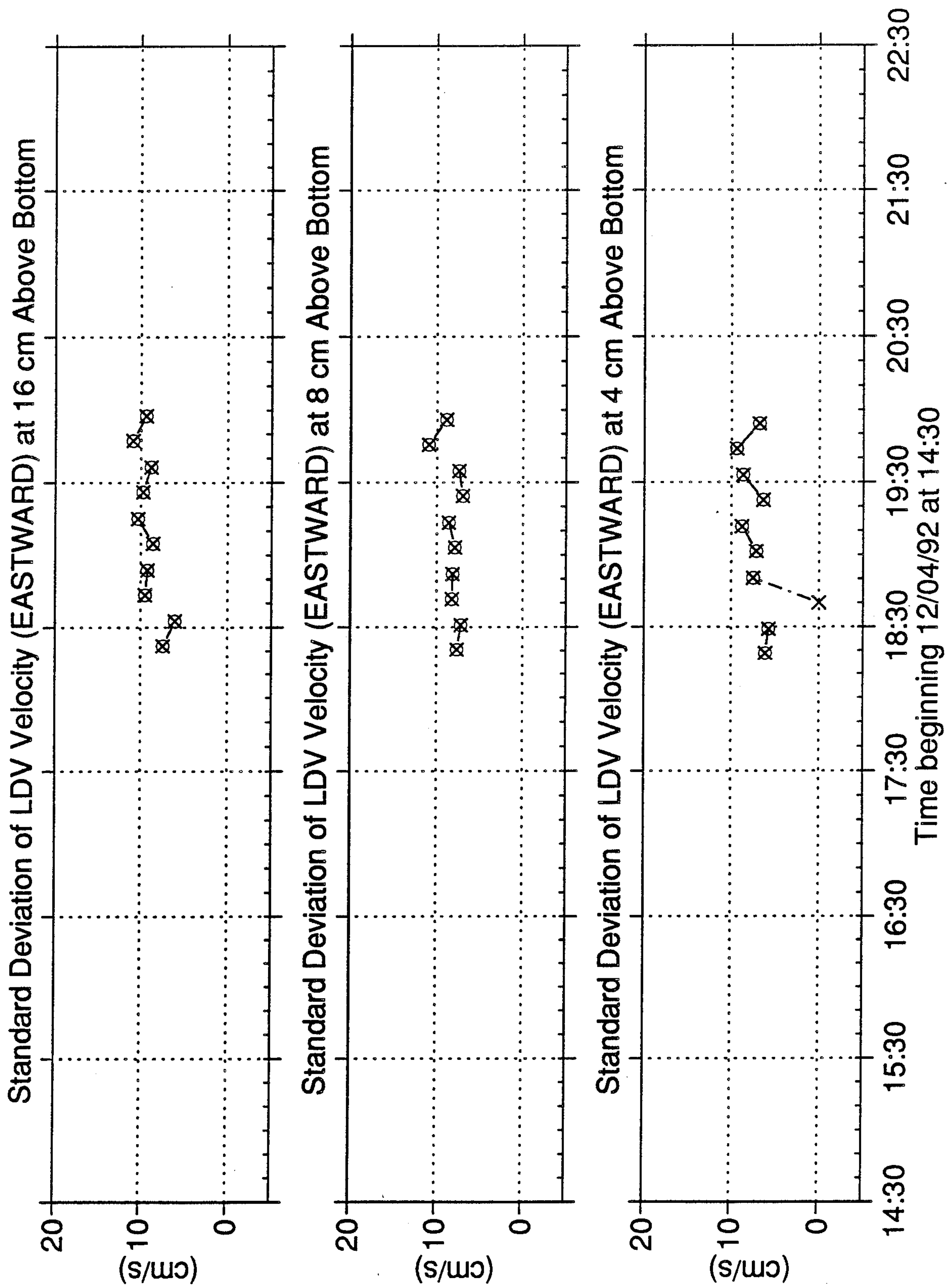
Figure 87.


Mean of LDV Velocity (EASTWARD) at 16 cm Above Bottom
Mean of LDV Velocity (EASTWARD) at 8 cm Above Bottom
Mean of LDV Velocity (EASTWARD) at 4 cm Above Bottom
(cm/s)
10
0
-10
14:30
15:30
16:30
17:30
18:30
19:30
20:30
21:30
22:30
Time beginning 12/04/92 at 14:30



Mean of LDV Velocity (EASTWARD) at 2 cm Above Bottom
Mean of LDV Velocity (EASTWARD) at 1 cm Above Bottom
Mean of LDV Velocity (EASTWARD) at .5 cm Above Bottom
(cm/s)
10
0
-10
14:30
15:30
16:30
17:30
18:30
19:30
20:30
21:30
22:30
Time beginning 12/04/92 at 14:30

Figure 88.


Standard Deviation of LDV Velocity (EASTWARD) at 16 cm Above Bottom
Standard Deviation of LDV Velocity (EASTWARD) at 8 cm Above Bottom
Standard Deviation of LDV Velocity (EASTWARD) at 4 cm Above Bottom
(cm/s)
20
10
0
14:30
15:30
16:30
17:30
18:30
19:30
20:30
21:30
22:30
Time beginning 12/04/92 at 14:30

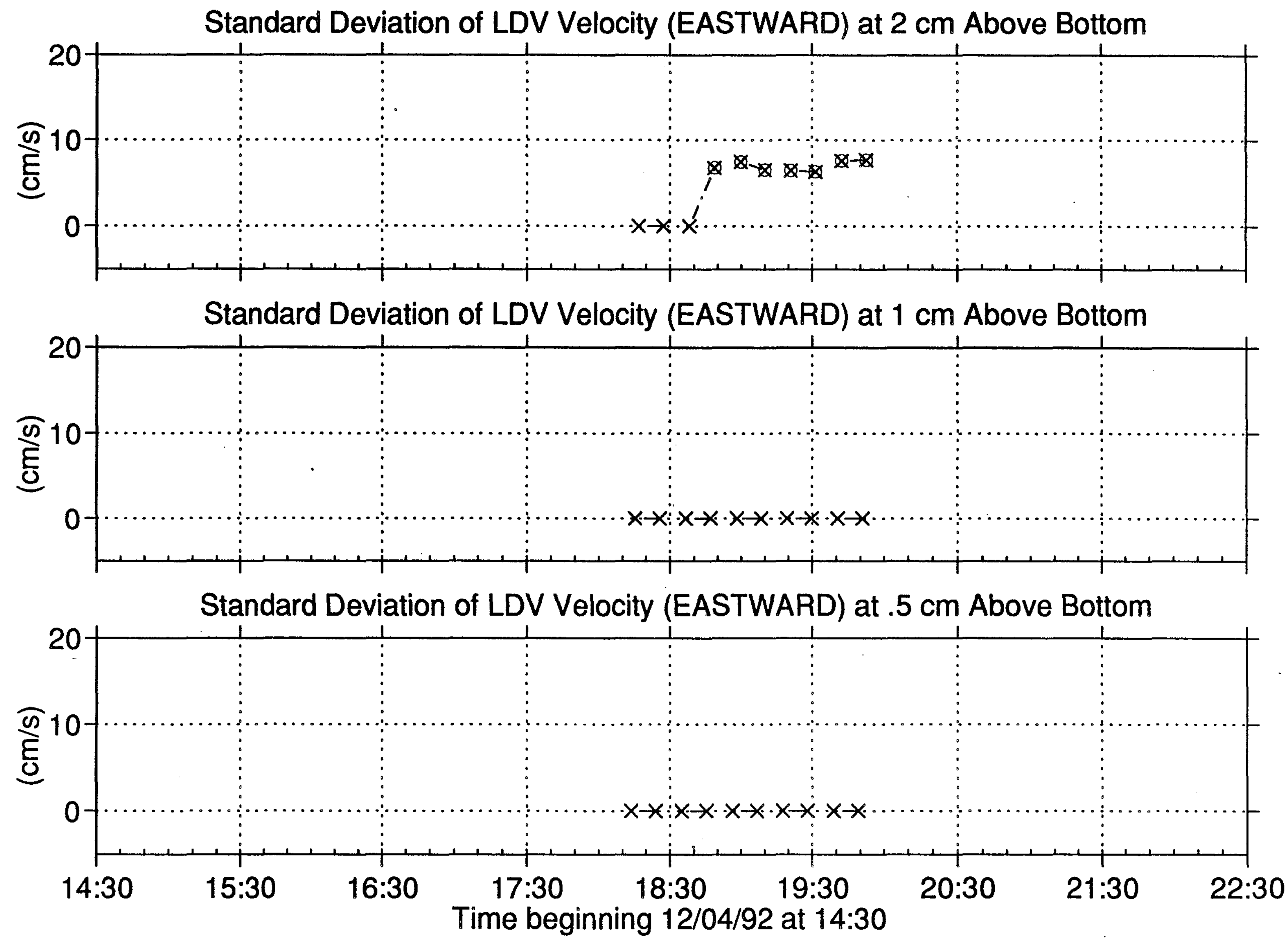

Standard Deviation of LDV Velocity (EASTWARD) at 2 cm Above Bottom
(cm/s)
20
10
0
Standard Deviation of LDV Velocity (EASTWARD) at 1 cm Above Bottom
(cm/s)
20
10
0
Standard Deviation of LDV Velocity (EASTWARD) at .5 cm Above Bottom
(cm/s)
20
10
0
14:30
15:30
16:30
17:30
18:30
19:30
20:30
21:30
22:30
Time beginning 12/04/92 at 14:30

Figure 89.

7. DATA FILE DOCUMENTATION

Data are archived as Matlab® files. A "set" refers to the twelve 90-second (25Hz) records, taken at each observation. (See Table 1.) A "group" refers to groups of sets and are described below and in Figure 14 of Section 4. There are three types of data files: a file for each set of twelve 90-second "snap-shots"; a file with statistical summaries of each of the 88-second records for the group of sets, as defined below; and, a file for each group containing concatenated time series. These provide a small scale time series (12 88 second snap-shots at 25 Hz), a medium scale, coarse time series (several hours with an observation each 1.5 minutes for BASS; and, an LDV observation at each elevation every 11 minutes or so); and, a medium scale, detailed time series (several hours of the 25 Hz concatenated BASS and LDV data). Since one of the groups is a superset, a long time series (20 hours) of statistical summaries is also provided.

7.1 88 Second Records

As shown in Table 1, each observation period includes a series of twelve 90 second observations. These were reduced to 88 second records in the processing, as described in Section 4. The twelve BASS records were all taken at the same elevation, which is approximately 21 cm above bottom, as shown in Figure 6. The twelve pressure records represent the pressure (in meters) above the pressure sensor, which was approximately 126 cm above bottom. The twelve LDV records contain the velocity at each of the following elevations: 0.5, 1, 2, 4, 8 ,16, 0.5, 1, 2, 4, 8 ,16 (cm above bottom). The data were corrected for phase shift (time lag) as described in Section 4. Each file contains:

pressure	2200x12	pressure series (meters)
time	1x12	time at beginning of each 88 second 25Hz record (days)
v	2200x12	NS-LDV velocity component (cm/s)
vqual	2200x12	NS-LDV quality field (>127+eps = valid data)
wne	2200x12	unrotated BASS (eastward + i*northward) (cm/s)

The files are named D2_0NN, where NN corresponds to the series as listed in Table 1 of Section 3. Each file is 1,056,222 bytes.

For D2_025-29, there also exists d2u_0NN files with EW-LDV data. Each file contains:

u	2200x12	EW-LDV velocity component (cm/s)
uqual	2200x12	EW-LDV presence field (eps=nodata; 128+eps=data accepted)
ulist	Kx1	list of eids which contain any valid processed data

where K represents the number of elevations which contains processed data.

7.2 Statistical Summaries

Data summary files were created in the processing stages. For each group, statistical summaries were created and stored as follows:

ebm	12xMM	E-W Bass Mean
ebs	12xMM	E-W Standard Deviation
intcp	2xMM	intercept of a polyfit of the NS-BASS with NS-LDV
slope	2xMM	slope of a polyfit of the NS-BASS with NS-LDV
mse	2xMM	Mean Square Error of LDV with BASS (with means removed)
nbm	12xMM	N-S Bass Mean
nbmnn	2xMM	N-S Bass Mean of only samples where there's valid LDV
nbs	12xMM	N-S Bass Standard Deviation
nbsnn	2xMM	N-S Bass Stdev of only samples where there's valid LDV
ng	12xMM	Fraction of NS-LDV data flagged as valid
pm	12xMM	Mean Pressure
ps	12xMM	Pressure Standard Deviation
sn1	1x1	NN (16-83) of first set in group
sn2	1x1	NN (16-83) of last set in group
t	12xMM	time (days)
vm	12xMM	Mean of Valid LDV
vs	12xMM	Standard Deviation of Valid LDV

The BASS data were rotated -5.4 degrees for alignment with the LDV. (See Section 5.) Where the number of rows is 12, each row corresponds to each elevation id and is associated with the time in each row of the time field. Where the number of rows is 2 (e.g., intcp), the first row correspond to the variable at elevation id 6; and, the second row correspond to the variable at elevation id 12. And, MM is the number of records in the group and can be tabulated as follows:

FileName (Snn.mat)	Number of Records (MM)	Series IDs	Filesize (bytes)
S16.mat	20	(D2_016 - D2_035)	21225
S36.mat	16	(D2_036 - D2_051)	17065
S52.mat	13	(D2_052 - D2_064)	16489
S66.mat	18	(D2_066 - D2_083)	22649
SS36.mat	48	(D2_036 - D2_083)	50345
SU25.mat*	5	(D2_025 - D2_039)	3611

SS36 is a 'superset' and will not fit in an eight hour window. These data require separate axis treatment. (See Appendix C.) SU25 has a different format, as it contains the EW statistical evaluations, rather than the NS.

7.3 Concatenated Time Series

To form extended time series, sets were concatenated for each group. The mean of each 88 second record is removed from each set, before it is concatenated. Each file contains:

ldvnn12	NS12x1	Valid NS-LDV at eid 12 for all series in group
ldvnn6	NS6x1	Valid NS-LDV at eid 6 for all series in group
nstart12	MMx1	index of first observation of each 88 second record in ldvnn12
nstart6	MMx1	index of first observation of each 88 second record in ldvnn6
nstop12	MMx1	index of last observation of each 88 second record in ldvnn12
nstop6	MMx1	index of last observation of each 88 second record in ldvnn6
sn1	1x1	NN (16-83) of first record in group
sn2	1x1	NN (16-83) of last record in group
t12	NS12x1	times corresponding to observances at NS12
t12all	MSx1	times corresponding to MS observances for eid 12
t6	NS6x1	times corresponding to observances at NS6
t6all	MSx1	times corresponding to MS observances for eid 6
ubass12	MSx1	Concatenated E-W BASS at eid 12 (MS=MM*2200)
ubass6	MSx1	Concatenated E-W BASS at eid 6 (MS=MM*2200)
vbass12	MSx1	Concatenated N-S BASS at eid 12 (MS=MM*2200)
vbass6	MSx1	Concatenated N-S BASS at eid 6 (MS=MM*2200)
vbnn12	NS12x1	NS-BASS at concurrent samples where Valid NS-LDV (eid: 12)
vbnn6	NS6x1	NS-BASS at concurrent samples where Valid NS-LDV (eid: 6)

NS6 and NS12 represent the total number of valid observations which are concatenated for elevation id (eid) 6 and elevation id (eid) 12, respectively. MM is the number of sets which were concatenated in the group. See Section 7.2. The file sizes are:

JR16.mat	2475702 bytes
JR36.mat	1826806 bytes
JR52.mat	1496470 bytes
JR66.mat	1957934 bytes

JR represents 'Joined and Rotated'. For the EW component, vbnn6,vbnn12,ldvnn6, and ldvnn12 variables are named ubnn6,ubnn12,ldunn6, and ldunn12, respectively, and stored in the data file JRu25.mat. The concatenated BASS files are not included in JRu25.

7.4 Miscellaneous

The file ST5U contains the start time (tstart) of the series S16. It is used in plotting the EW velocity components (JRu25) in the same time profile as the S16 series.

8. ACKNOWLEDGEMENTS

We would like to acknowledge the excellent support of the U.S. Army Corps of Engineers, Coastal Engineering Research Center, Field Research Facility, Kitty Hawk, NC, 27949. Specifically, we would like to thank Bill Birkemeier, Director of the FRF, for his cooperation and Gene Bicherer for coordinating the logistical support.

We also thank the divers of Max Marine, Kill Devil Hills, NC, 27948.

We also acknowledge Chuck Pottsmith, NorthWest Research Associates, Bellevue, WA, for his engineering support in the development of the LDV profiler.

We thank the graphics illustrator, Betsey Doherty, Woods Hole Oceanographic Institution, for her contributions to this document.

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9. REFERENCES

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APPENDIX A.

SUPPLEMENTAL INFORMATION FROM U.S. ARMY CORPS OF ENGINEERS

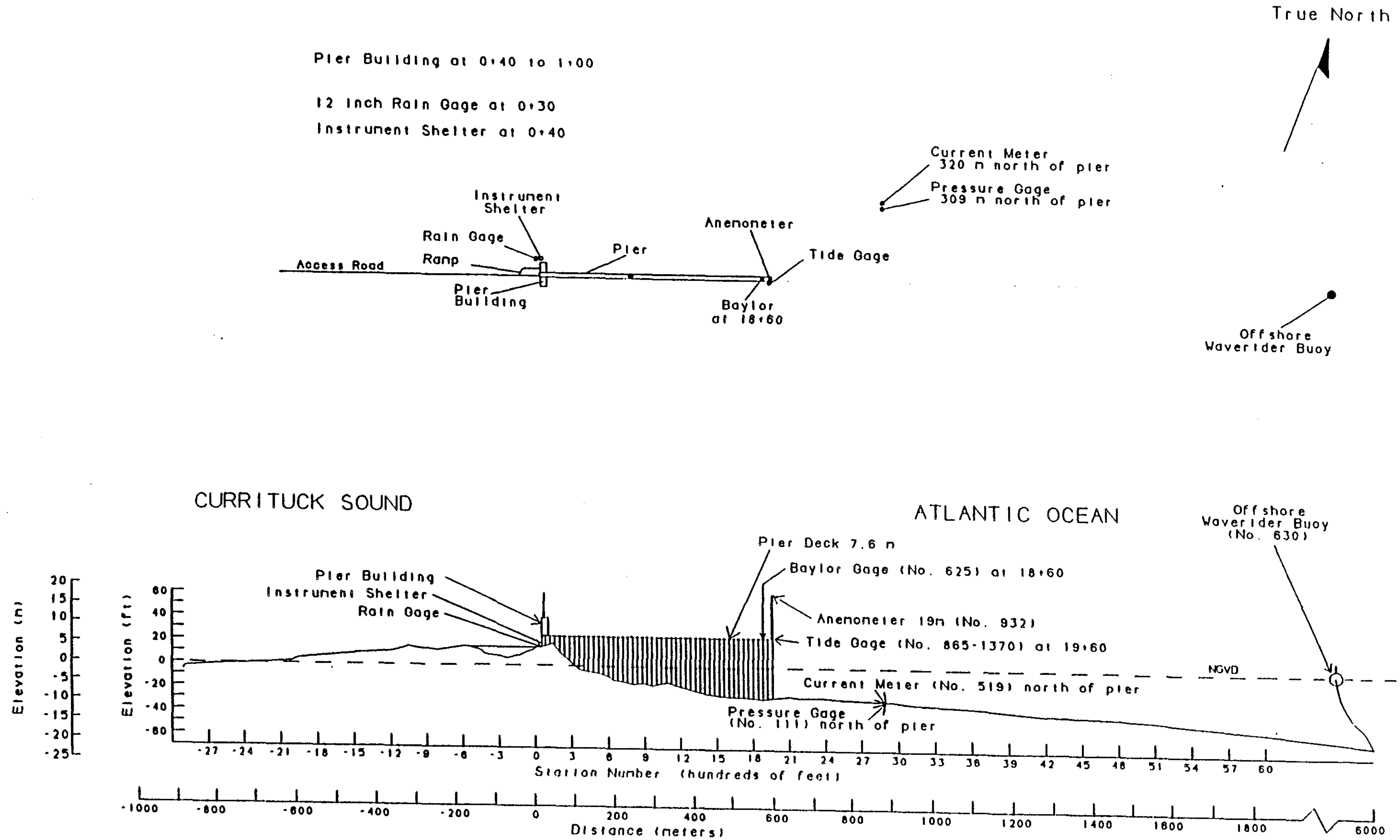
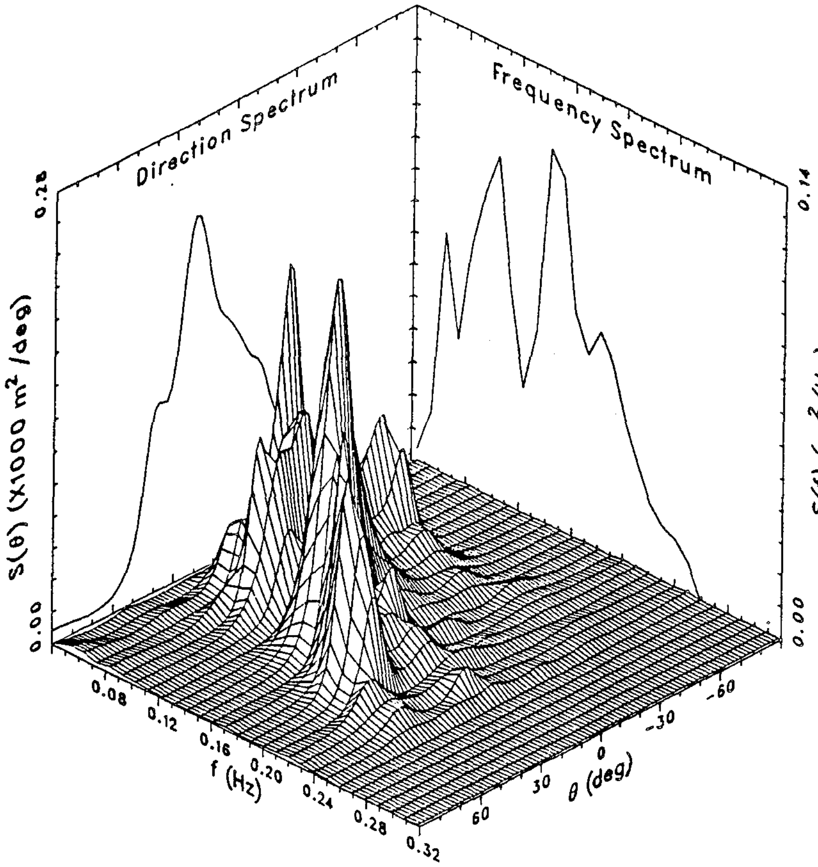
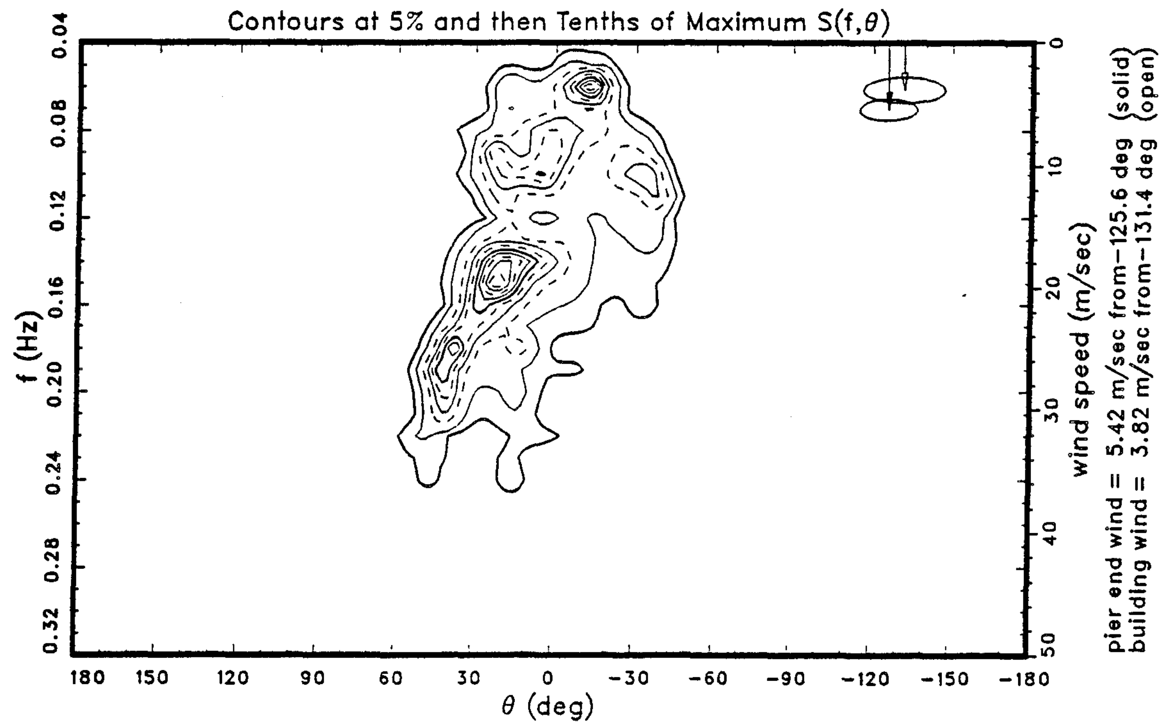


Figure A-1. Instrument locations at FRF (all elevations from NGVD, all distances from FRF baseline).

Figure A-[2:12] Directional Spectra recieved from U.S. Corps of Engineers (where 0° is East; +45° is NorthEast; and, -45° is SouthEast.)

FRF 8–m Array Frequency–Direction Spectrum
Date: 04 Dec 92 at 1300 EST for 136.53 min with 160 dof
H_{mo} = 0.43 m f_p = 0.142 Hz T_p = 7.04 sec θ_p = 18.0 deg
depths: min = 8.50 m mean = 8.57 m max = 8.60 m at gage 191



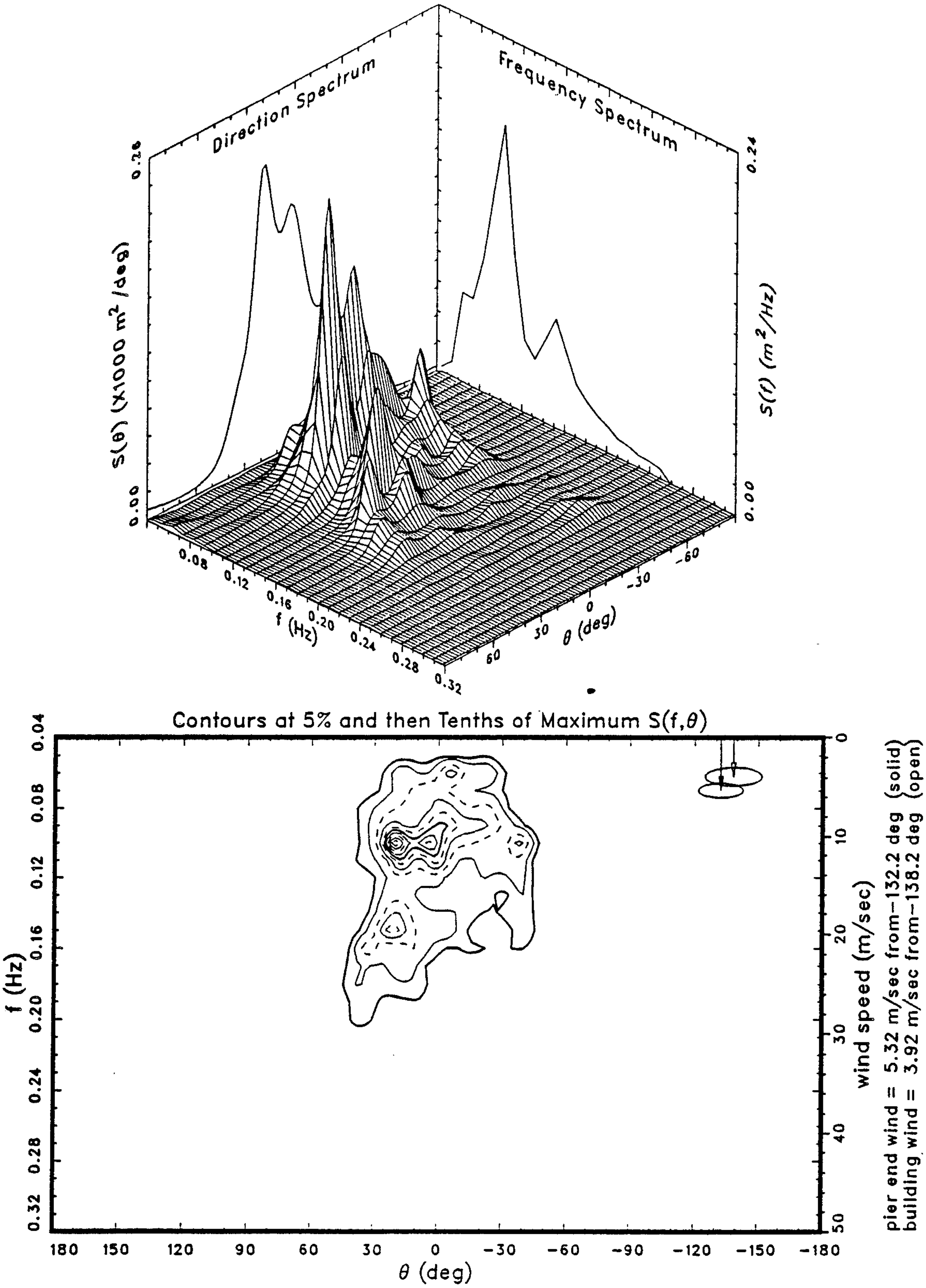


FRF 8–m Array Frequency–Direction Spectrum

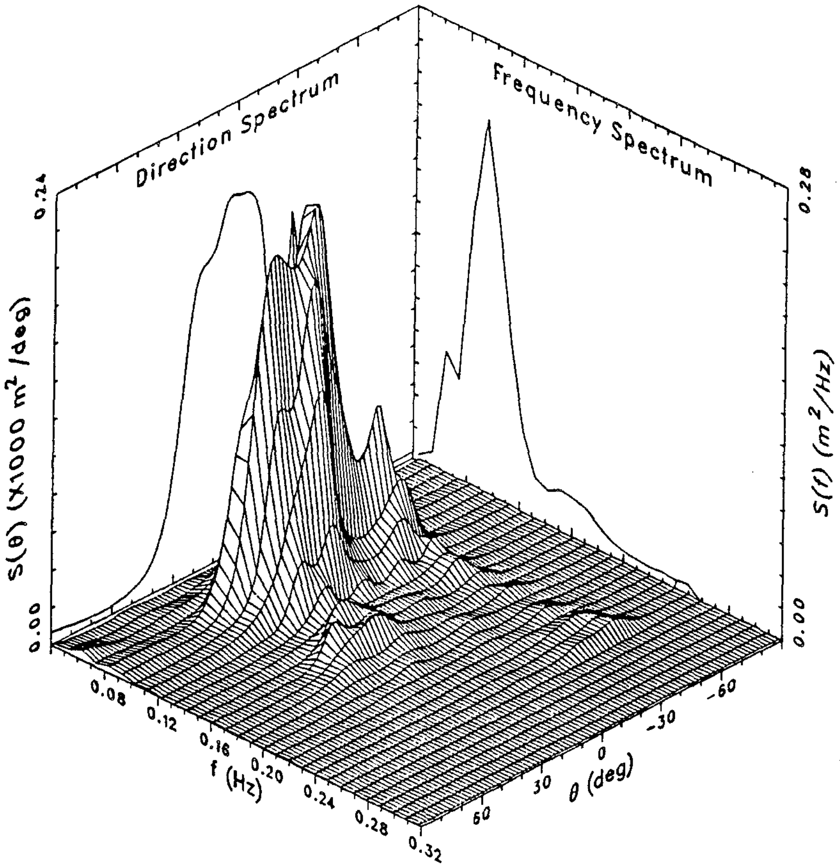
Date: 04 Dec 92 at 1600 EST for 136.53 min with 160 dof

H_{mo} = 0.41 m f_p = 0.103 Hz T_p = 9.71 sec θ_p = 20.0 deg

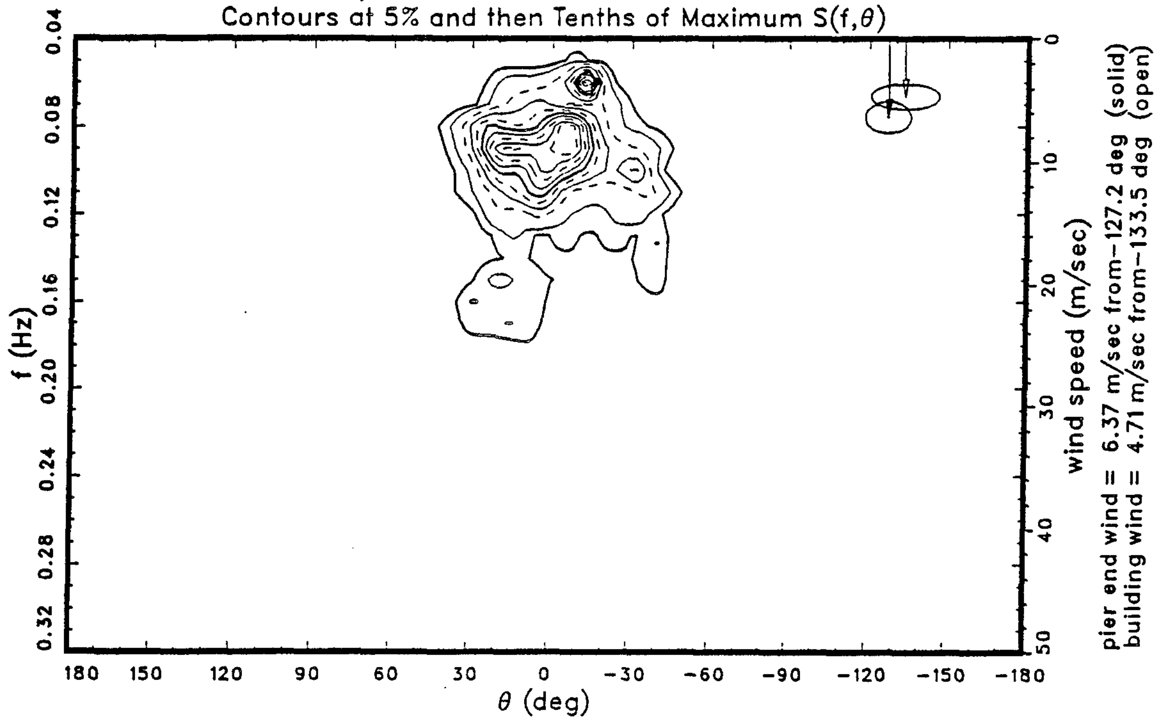
depths: min = 8.19 m mean = 8.38 m max = 8.54 m at gage 191



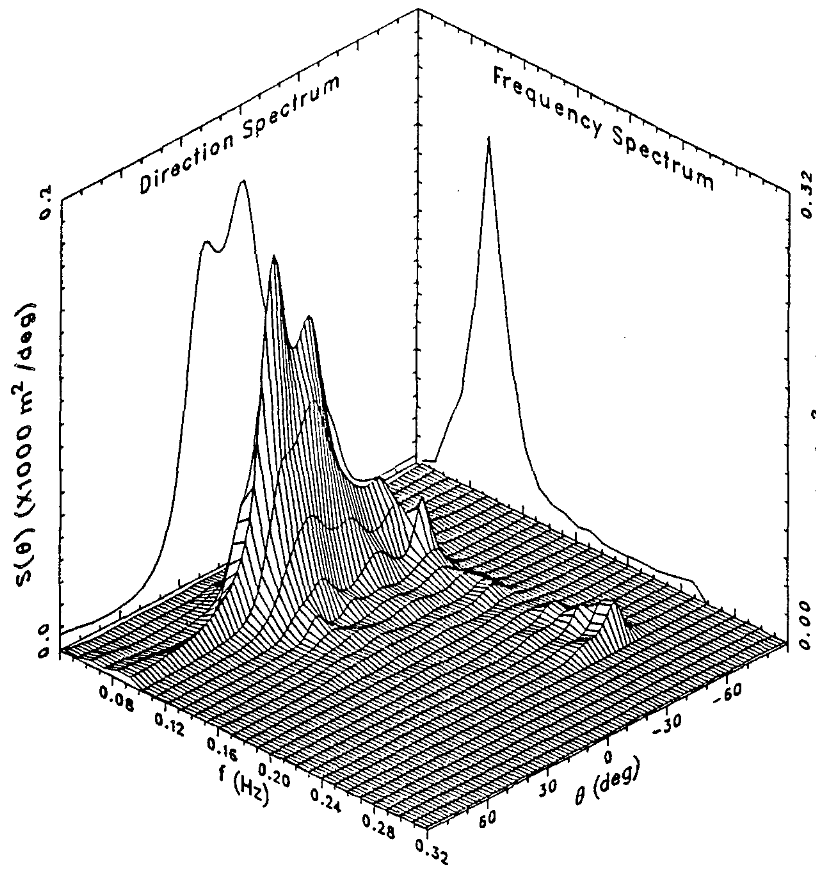
FRF 8–m Array Frequency–Direction Spectrum
Date: 04 Dec 92 at 1900 EST for 136.53 min with 160 dof
H_{mo} = 0.41 m f_p = 0.093 Hz T_p =10.72 sec θ_p = −6.0 deg
depths: min = 7.87 m mean = 7.92 m max = 8.03 m at gage 191



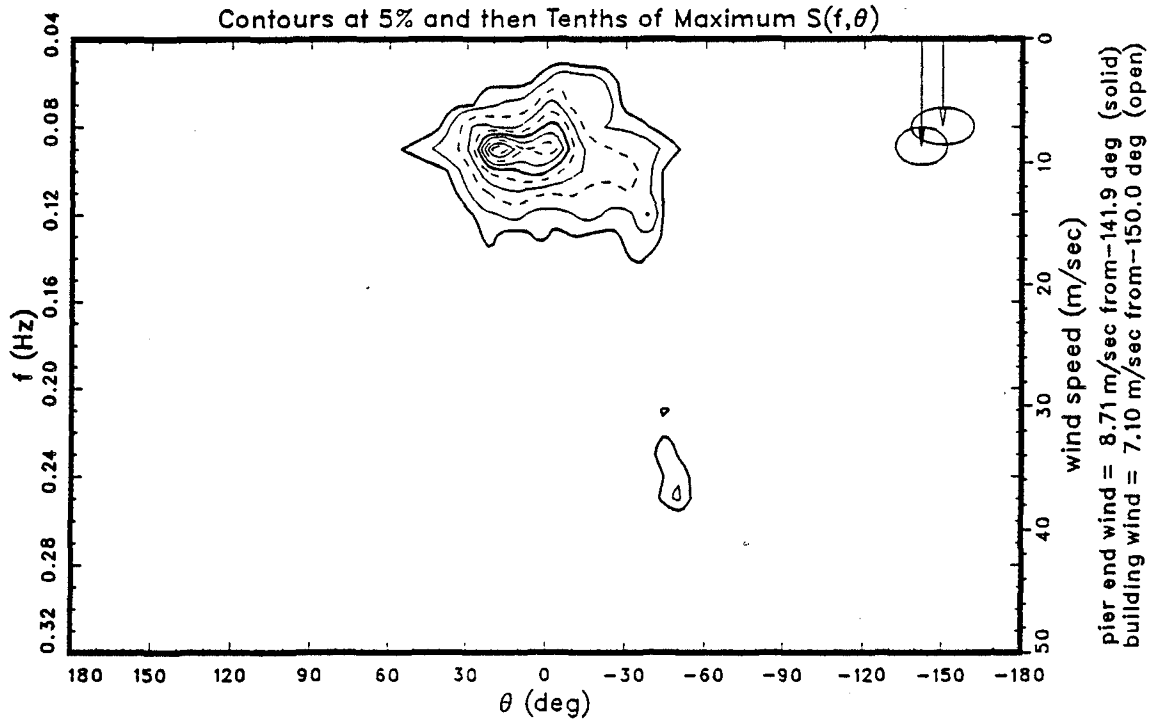
Contours at 5% and then Tenths of Maximum S(f,θ)



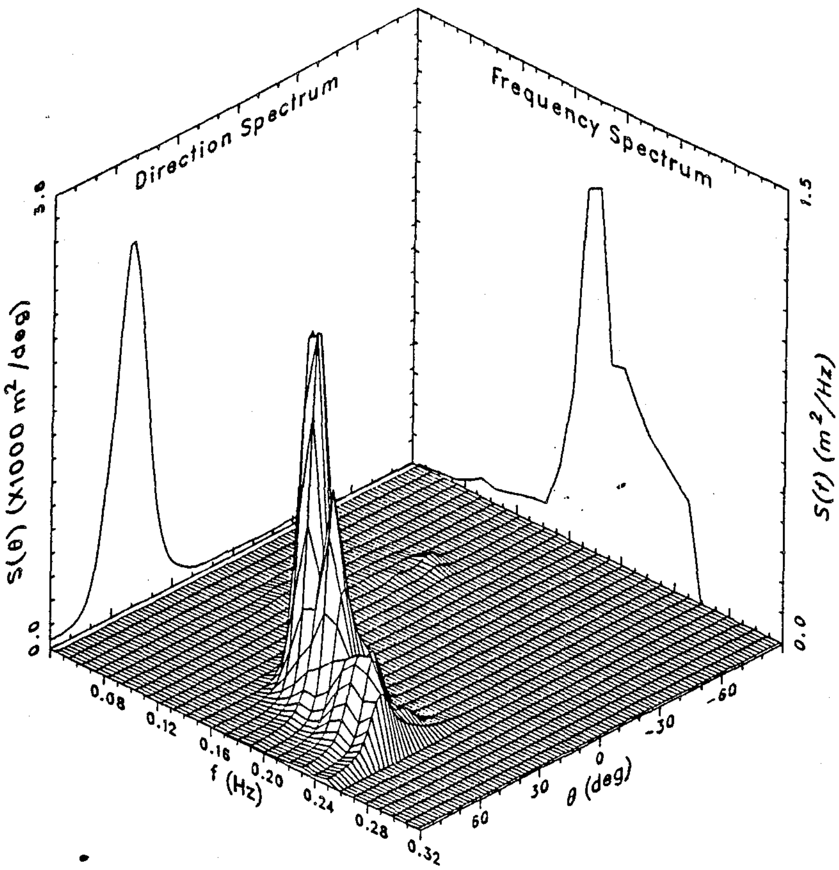
FRF 8–m Array Frequency–Direction Spectrum
Date: 04 Dec 92 at 2200 EST for 136.53 min with 160 dof
H_{mo} = 0.39 m f_p = 0.093 Hz T_p =10.72 sec θ_p = 18.0 deg
depths: min = 8.00 m mean = 8.12 m max = 8.27 m at gage 191



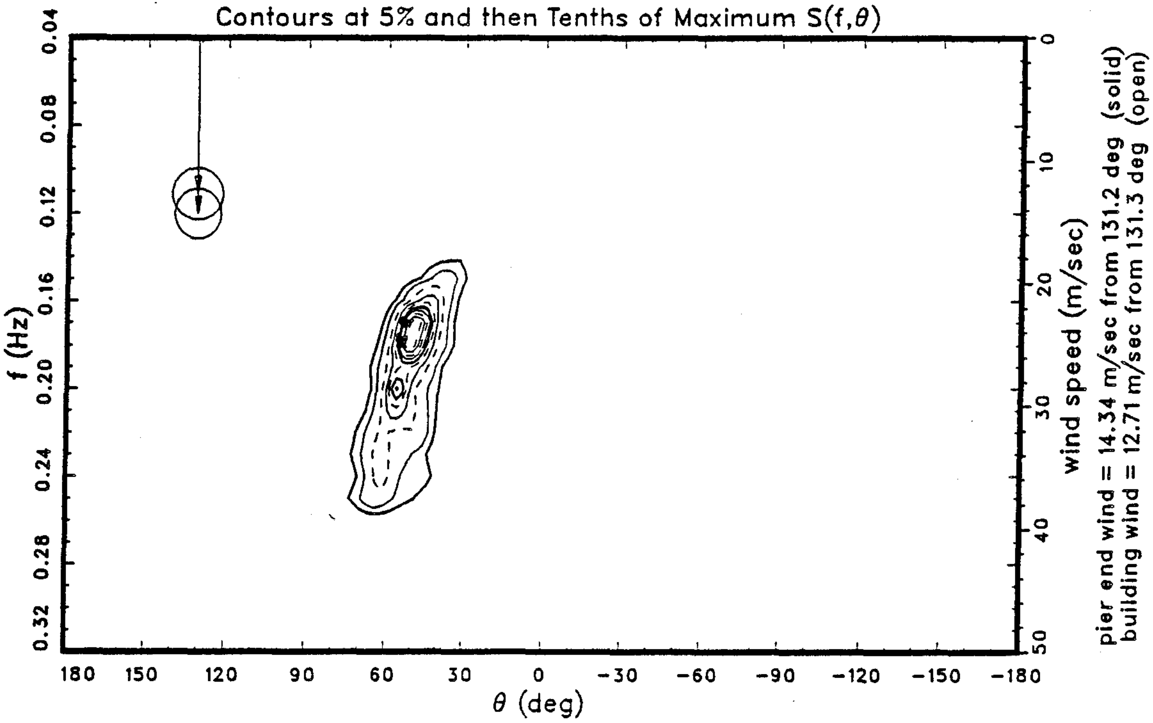
Contours at 5% and then Tenths of Maximum S(f,θ)



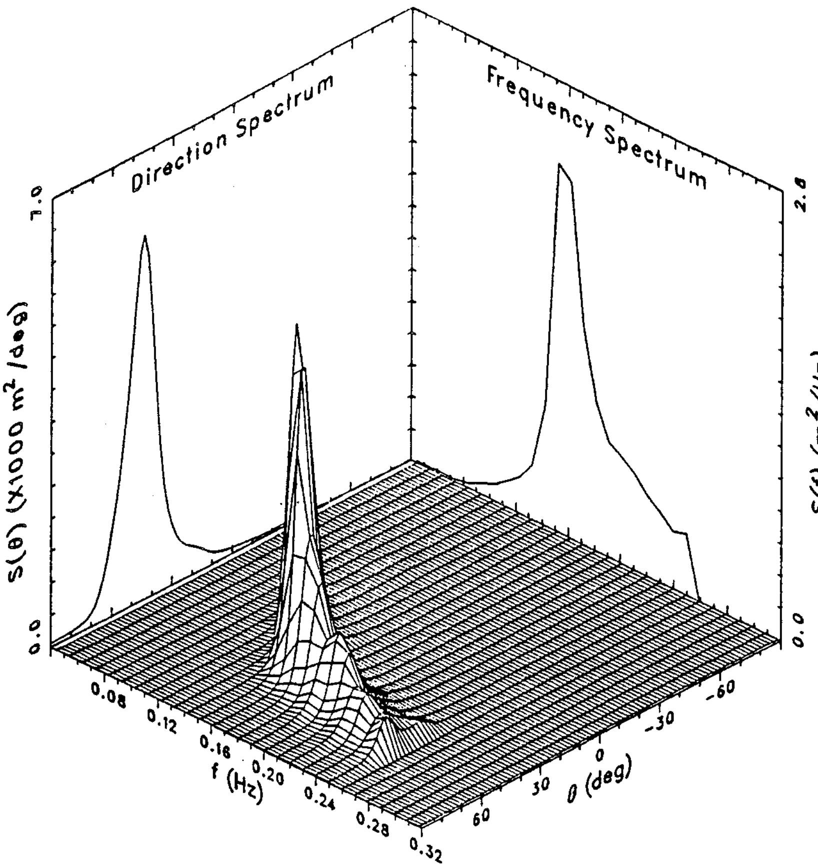
FRF 8–m Array Frequency–Direction Spectrum
Date: 05 Dec 92 at 1300 EST for 136.53 min with 160 dof
H_{mo} = 1.05 m f_p = 0.181 Hz T_p = 5.52 sec θ_p = 52.0 deg
depths: min = 8.19 m mean = 8.39 m max = 8.61 m at gage 191



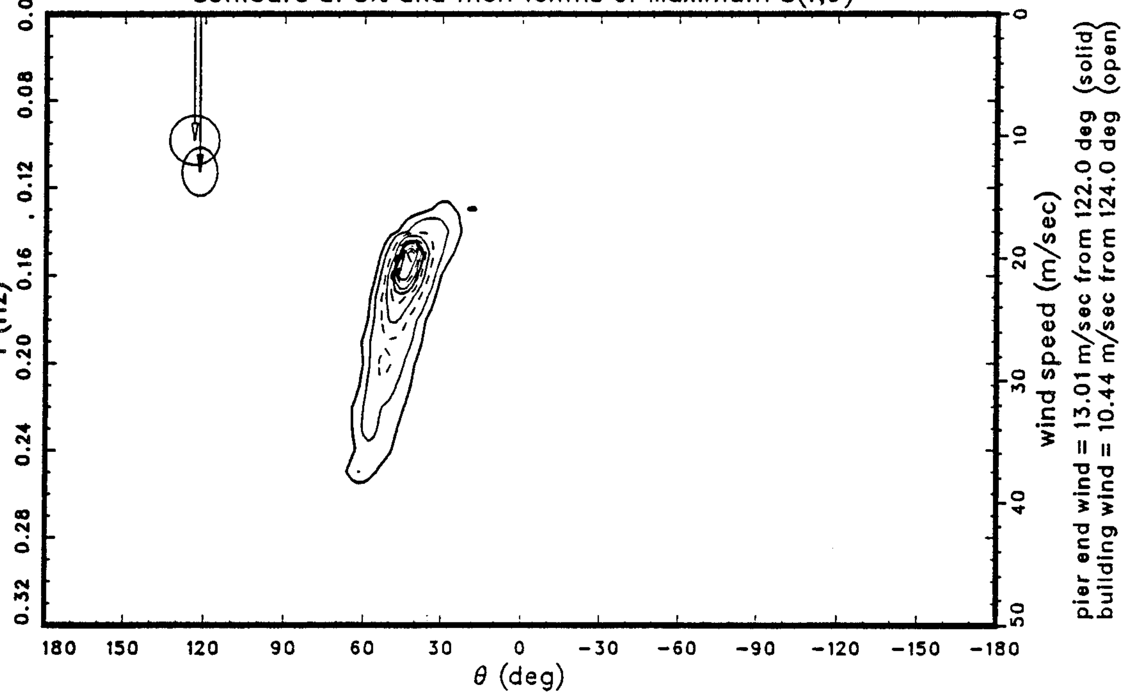
Contours at 5% and then Tenths of Maximum S(f,θ)



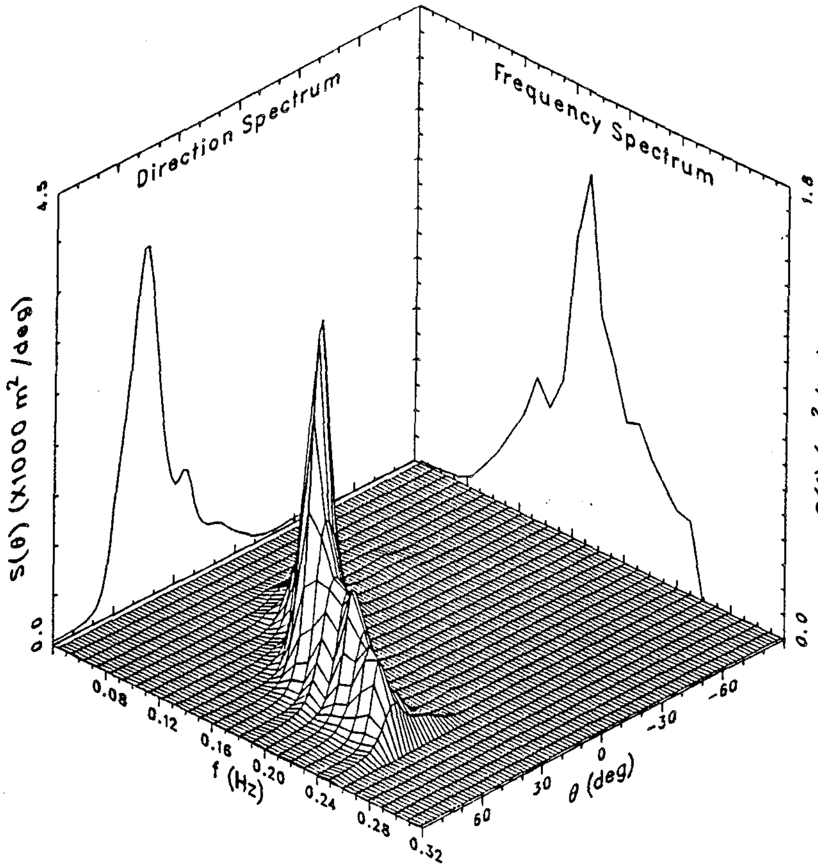
FRF 8-m Array Frequency-Direction Spectrum
Date: 05 Dec 92 at 1600 EST for 136.53 min with 160 dof
H_{mo} = 1.38 m f_p = 0.152 Hz T_p = 6.59 sec θ_p = 42.0 deg
depths: min = 8.33 m mean = 8.42 m max = 8.51 m at gage 191

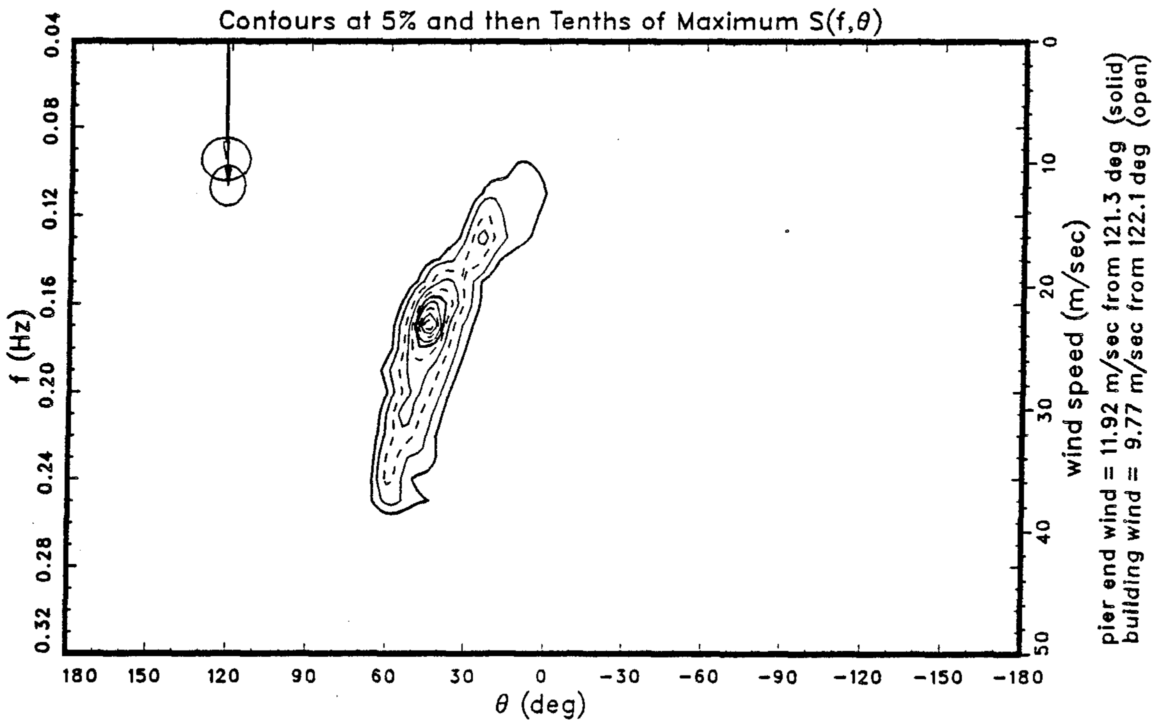


Contours at 5% and then Tenths of Maximum S(f,θ)

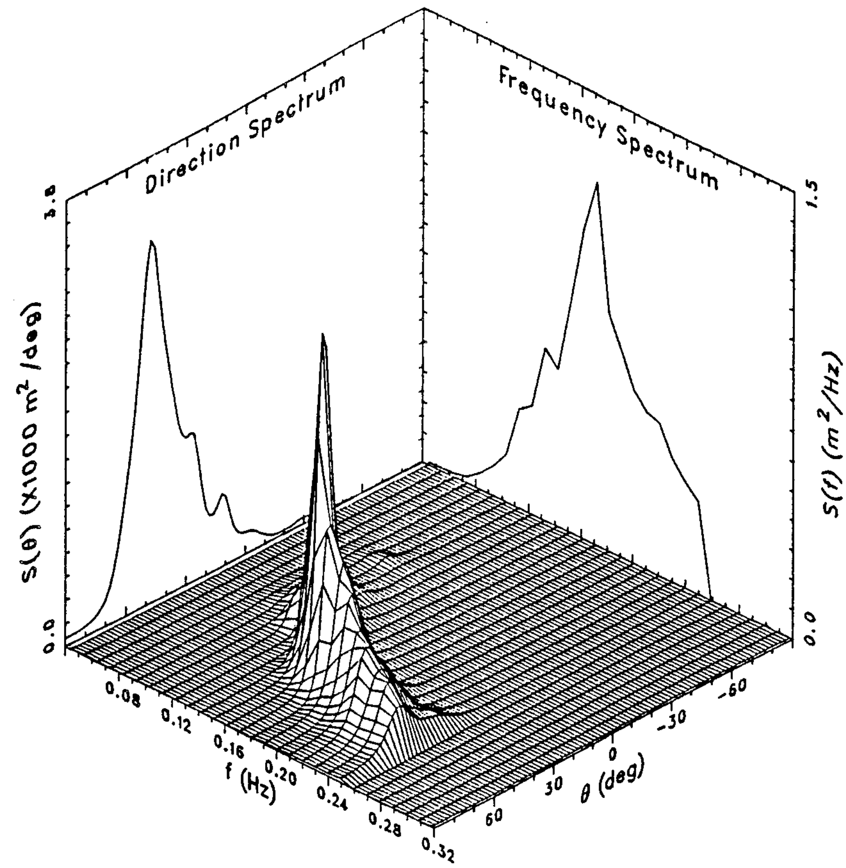


FRF 8–m Array Frequency–Direction Spectrum
Date: 05 Dec 92 at 1900 EST for 136.53 min with 160 dof
H_{mo} = 1.23 m f_p = 0.171 Hz T_p = 5.83 sec θ_p = 44.0 deg
depths: min = 7.82 m mean = 7.94 m max = 8.13 m at gage 191

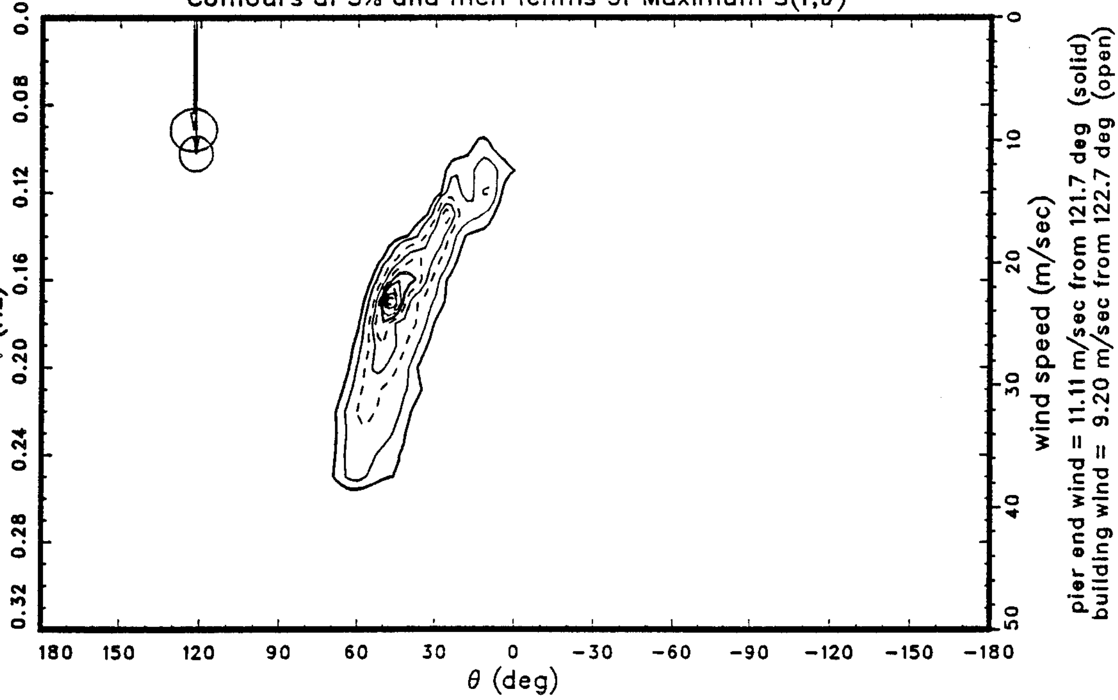




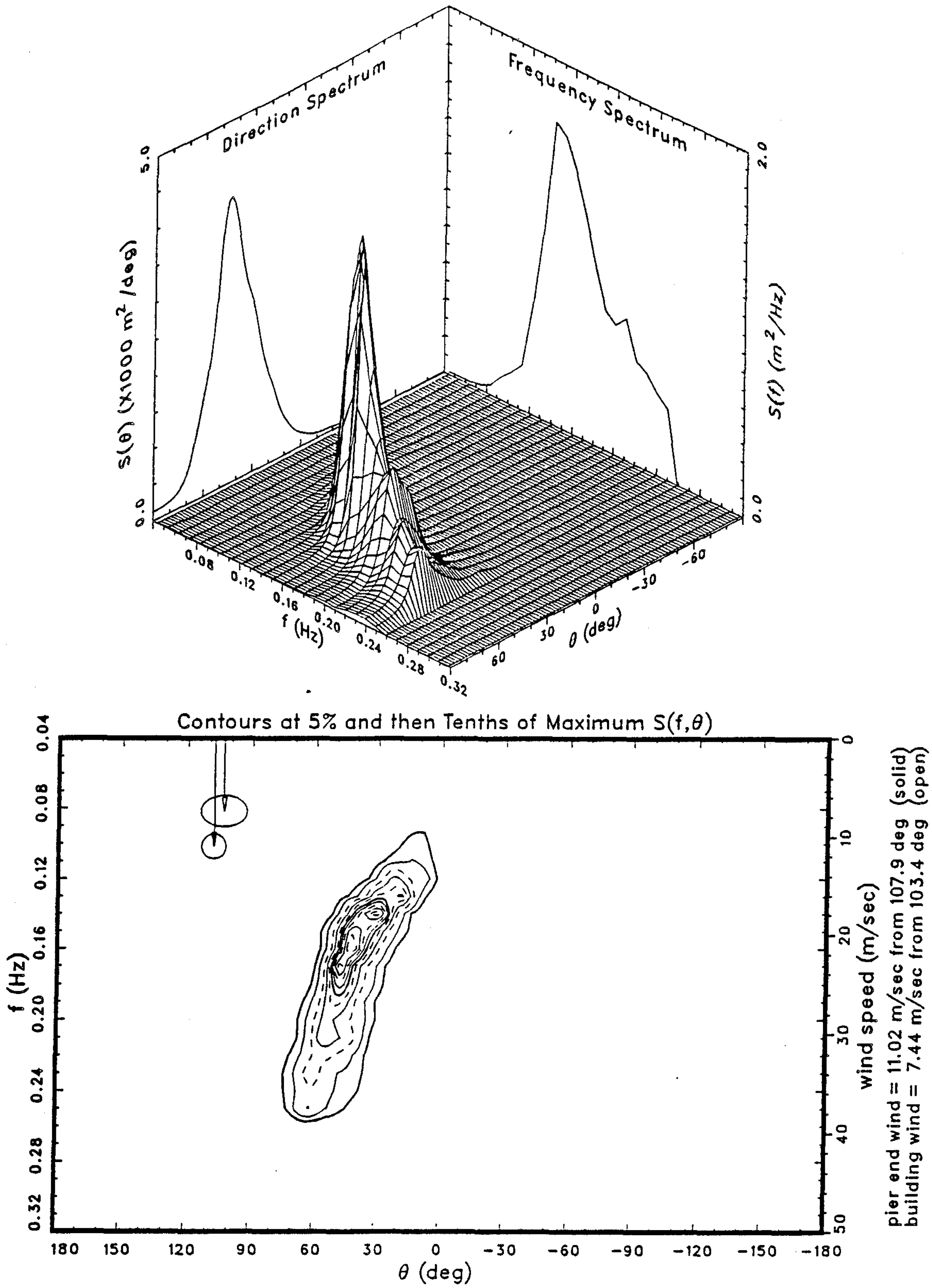
FRF 8–m Array Frequency–Direction Spectrum
Date: 05 Dec 92 at 2200 EST for 136.53 min with 160 dof
H_{mo} = 1.21 m f_p = 0.171 Hz T_p = 5.83 sec θ_p = 48.0 deg
depths: min = 7.89 m mean = 8.02 m max = 8.20 m at gage 191



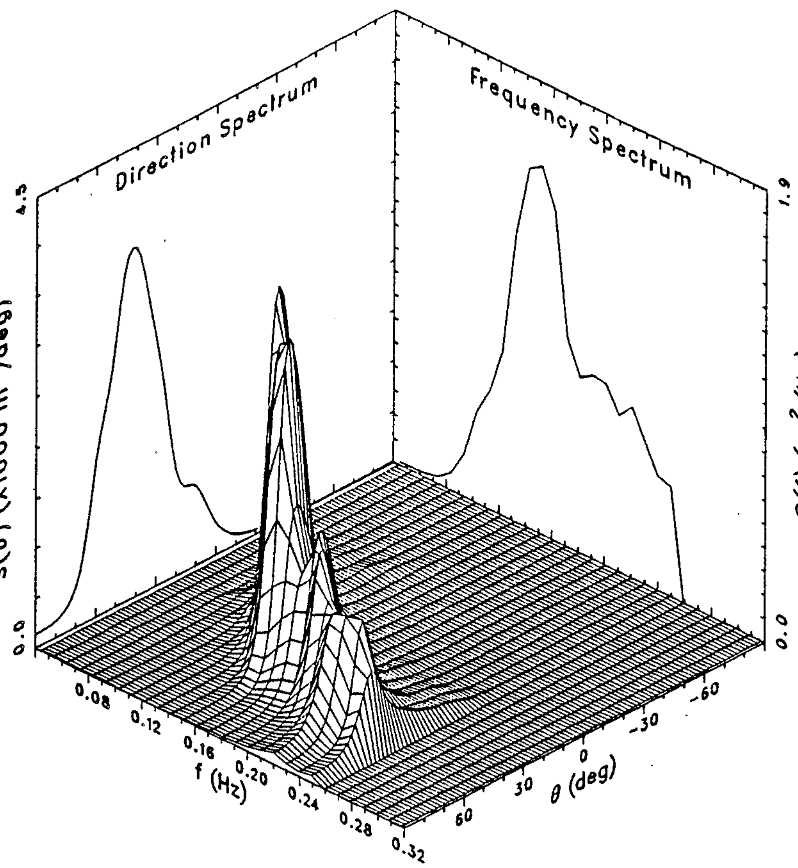
Contours at 5% and then Tenths of Maximum S(f,θ)

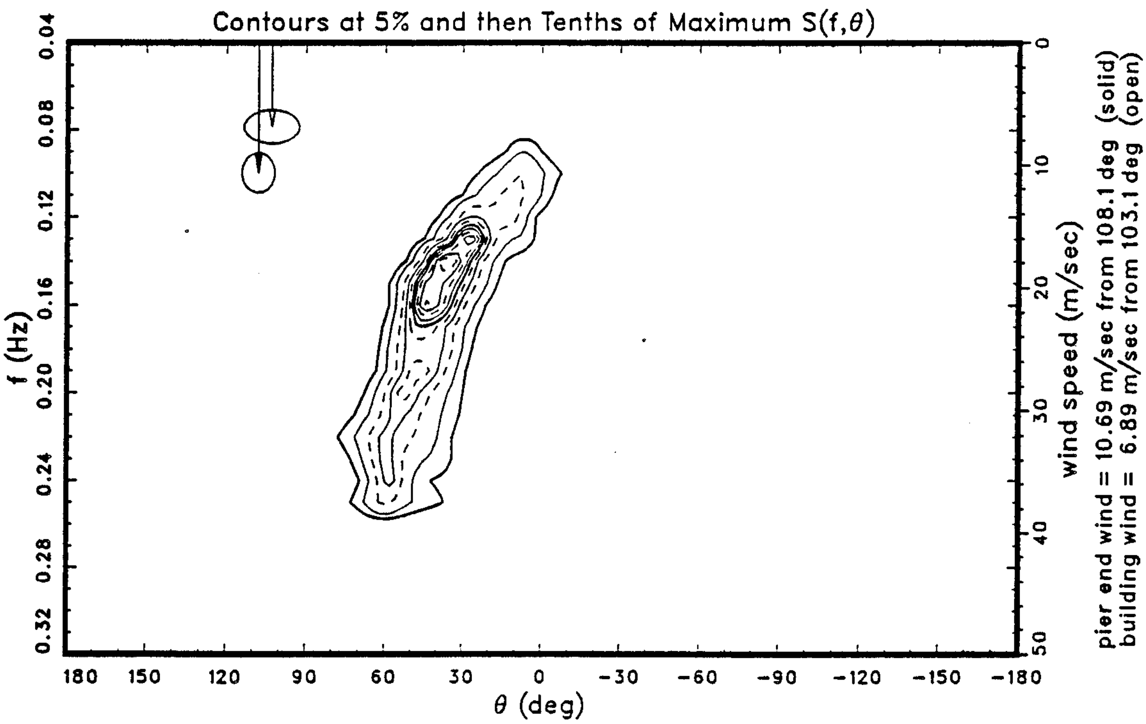


FRF 8–m Array Frequency–Direction Spectrum
Date: 06 Dec 92 at 0100 EST for 136.53 min with 160 dof
H_{mo} = 1.45 m f_p = 0.142 Hz T_p = 7.04 sec θ_p = 30.0 deg
depths: min = 8.42 m mean = 8.59 m max = 8.79 m at gage 191

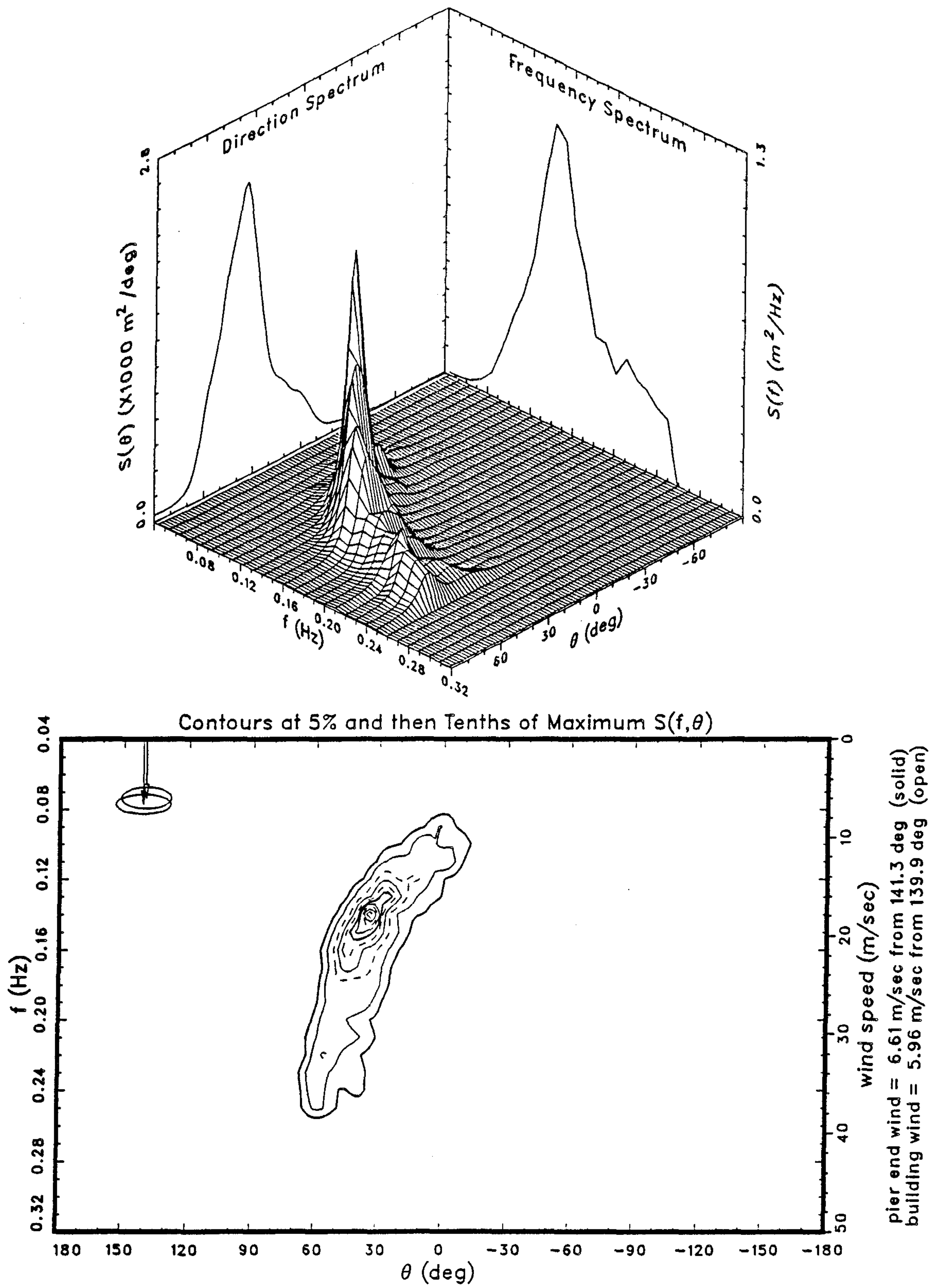


FRF 8–m Array Frequency–Direction Spectrum
Date: 06 Dec 92 at 0400 EST for 136.53 min with 160 dof
H_{mo} = 1.46 m f_p = 0.152 Hz T_p = 6.59 sec θ_p = 42.0 deg
depths: min = 8.76 m mean = 8.86 m max = 8.92 m at gage 191





FRF 8–m Array Frequency–Direction Spectrum
Date: 06 Dec 92 at 0700 EST for 136.53 min with 160 dof
H_{mo} = 1.15 m f_p = 0.142 Hz T_p = 7.04 sec θ_p = 34.0 deg
depths: min = 8.12 m mean = 8.31 m max = 8.53 m at gage 191



APPENDIX B.

PROCESSING SOFTWARE

The programs listed below are included in this section to further document the processing of the data presented in this report.

B-1. Description of BASS Data Collection and Storage (Submitted by A.J.Williams 3rd)

B-2. bin2mat.c - file conversion (binary to MATLAB®)) of LDV (counts to cm/s) and pressure (counts to meters). NOTE: EW-LDV was processed separately. The gain factor was (1.0) and a 32 (cm/s) offset was subtracted in the conversion of counts to cm/s.

B-3. joinlb.m - loading of ASCII BASS; conversion of BASS counts (10Hz) to cm/s (25Hz); adjustment of pressure (meters); and, time adjustment.

B-4. makeseries.m - loads data in groupings (as described in Section 7); rotates BASS; computes statistics; and saves a (SNN.mat) summary.

B-5. joinseries.m - joins timeseries of individual 88 second observations into time series as described in Section 7. Stores series with corresponding times in files JRNN.mat. (BASS data are rotated.)

B-6. specden.m - computes velocity spectra from BASS Velocity and Pressure (see Section 5.1).

B-7. pfit4.m - processes EW-LDV removing the outliers which were flagged as valid (see Section 4).

B-8. maxpoint.m - determines LDV points to keep based on polynomial fit through valid data (see Section 5).

DuckBASS Documentation, YogiDuck Version October 16, 1992
Albert J. Williams 3rd

Configuration

DuckBASS is a Model 4 based BASS with up to three acoustic current sensors. It has a trigger input and RS485 output. It uses a combined transmit/receive card for compactness. With three sensors, DuckBASS is 6.6" long. The endcaps of the 7" diameter case are held on with plastic V-Band material and a hose clamp composed of size 80 and size 40-64 mm. The endcaps take a 162 radial O-ring and 165 axial O-ring. The case is 16" long.

Sensitivity

The DT-V board in DuckBASS has a full scale range of +/-240 cm/s for a reading of 0FFF for + full scale and F000 for - full scale. Zero velocity is 0000 or FFFF and a missed measurement is flagged with the number 8000. Basically, BASS is a 12 bit-plus-sign system and does 2's complement representation of negative numbers. To convert a BASS integer to velocity component, check for 8000 hex and discard, then subtract 65536 from any number with a leading one (greater than 32767).

Numbers without a leading one are positive and will range from 0 to 4095. Nanosecond delays were used to calibrate this DT-V board. The reading was taken with 0ns, 40ns taken three different ways, 80ns taken two ways, and 120ns for positive and negative delays. The average was 13.35 bits/ns. The scale factor is 1.333 ns/cm/s so this converts into .056 cm/s/bit. True full scale is 4095 bits or 230 cm/s. To obtain the horizontal velocity subtract the second BASS measurement in the output record from the fourth and divide by root two and multiply by .056 for the x velocity. The y velocity is obtained by subtracting the first from the third, dividing by root two and multiplying by .056. The vertical velocity is the negative sum of the four components divided by twice root two and multiplied by .056. Purely horizontal flows as great as 340 cm/s can be measured without going off scale but orbital flows will be clipped at a speed that could be as low as 240 cm/s depending on the azimuth of the orbit.

Program

The program in battery protected RAM on October 16, 1992 is a 12.5 Hz sample rate of a single acoustic current meter sensor. It starts running about 5 seconds after power on, when the assembly code has been loaded and assembled. Its clock is started at zero each time it is powered on but then counts from 0000 January 1, 1980 in seconds.

Each record is an ASCII single line output of hex "EE" and four hex measurements of velocity. The timing is controlled by the command on line 1230, "SLEEP 8". This TTBasic command waits for the internal clock to advance by 8 ticks of 1/100 second from the last execution of a SLEEP command. If the clock has already passed the set time interval, an asterisk will be output. If this time is made shorter, asterisks start to appear indicating timer overrun, and the sample rate will be irregular. Much of the time is spent on the ASCII output. The sample rate can be increased somewhat by switching to binary output by replacing 1142 with the statement PRINT {0,8}:GOTO 1230. At the expense of greater power drain, another 10 ms per sample can be shaved off by powering BASS continuously. Delete 8110, 8310, and 8780. This leaves power on and doesn't provide warmup time.

To reprogram the BASS, open the case and plug a phone to RS232

cable into the Model 4 and power on BASS. Plug the DB25 connector into a computer running a terminal program (Ttools from Onset works well.) Hit ^C to get the "OK" prompt. Then edit the appropriate lines or type "NEW" and download the new program. Type "RUN" and observe execution on the terminal. If it needs work, type ^C and get the prompt to load another. The program won't go away when the power is removed. It will start running when power is applied.

Power

BASS running at 12.5 Hz takes 45 ma from 16 to 32 volts. The SN75158 Line Driver increases this to 65 ma. The case is internally isolated from ground but has a 3.3 uF ceramic capacitor from negative battery to chassis. This should prevent the voltage drop in the negative power lead causing terrible corrosion to the case.

Zeros

The cables to the acoustic sensor must be dressed and tie wrapped well so they don't move before obtaining a zero calibration. Put a bag over the sensor and put it in a bucket of water. Run BASS for several minutes and average the readings. This is a good estimate of the in situ zero flow reading and must be subtracted from all field measurements.

Program - YOGIDUCK.TTB

```
  10 GOTO 1000
 100 STOP
1000 REM YOGIDUCK OCT-16-92
1010 X=0:A=0:B=0:C=0:D=0:E=0:F=0:G=0:H=0:REM ASSEMBLY ROUTINES
1015 PRINT #06H,A,B,C,D,E,F,G,H,X
1020 GOSUB 8000              :REM FIRST PASS
1025 PRINT #06H,A,B,C,D,E,F,G,H,X
1030 GOSUB 8000              :REM SECOND PASS
1031 PRINT #06H,A,B,C,D,E,F,G,H,X
1032 GOSUB 8000              :REM THIRD PASS
1035 PRINT #06H,A,B,C,D,E,F,G,H,X
1040 PCLR 7,8,9,10,11,12,13,14,15   :REM ESTABLISH DDRs
1050 ASM &HBB,DB &H02        :REM A/D BIPOLAR,TURNS OFF,12 BIT
1060 PRINT 'Waiting for event'
1064 SLEEP 100
1066 IF PIN(0)=1 GOTO 1070  :REM event
1067 GOTO 1060
1070 PRINT 'Event detected at':PRINT 'Day,hr,min,sec since power on':RTIME
1071 FOR I=1 TO 4
1072 PRINT #4,?(4-I);
1073 NEXT I
1074 PRINT:SLEEP 0
1085 FOR N=1 TO 900          :REM 90 SEC PROGRAM-72 SEC AT 80ms SAMPLE TIME
1090 X=0                     :REM INITIALIZE DATAFILE
1092 STORE X,#1,&HEE
1120 CALL &H7300,0        :REM CALL A/D ROUTINE
1130 CALL &H73B0,0        :REM CALL SUBTRACT AND TRANSFER
1140 X=0                     :REM REINITIALIZE DATAFILE
1142 PRINT #2H,GET(X,#1)," ";
1170 FOR L=1 TO 4            :REM 4 BASS AXES
1180 PRINT #04H,GET(X,#2)," ";
1190 NEXT L                  :REM FOUR AXES/LINE
1200 PRINT
```

```
1230 SLEEP 8                :REM WAIT OUT THE 80ms
1240 NEXT N                  :REM      -------------------------
1250 REM DONE                     :REM GO TO LOW POWER
1260 GOTO 1060                    :REM LOOP

8000 X=&H7460               :REM MULTIPLEXOR LIST, NORMAL ORDER
8010 ASM X,DW &H0000;DW &H8000;DW &H4000;DW &HC000
8015 ASM X,DW &H2000;DW &HA000;DW &H6000;DW &HE000
8050 ASM X,DW &HFFFF;DW &HFFFF   :REM END OF LIST
8055 G=X

8100 X=&H7300               :REM BASS ROUTINE
8110 ASM X,SLP                 :REM START TIMING AT END OF SLP
8120 ASM X,LDAA &H17
8130 ASM X,ANDA #&H47
8140 ASM X,ORAA #&H40
8150 ASM X,STAA &H17           :REM PORT 6,0100 0XXX,PWR ON,/CS=1
8160 ASM X,LDX #&H7400         :REM INDEX TO MUX LIST AND OUTPUT
8170 ASM X,LDAB &H60,X
8180 ASM X,STAB &H03           :REM PORT 2
8190 ASM X,TAB
8200 ASM X,ORAB #&H08
8210 ASM X,STAB &H17           :REM CLOCK HIGH,0100 1XXX
8220 ASM X,STAA &H17           :REM 1st FALLING EDGE
8230 ASM X,STAB &H17
8240 ASM X,STAA &H17           :REM 2nd FALLING EDGE,ACCEPTS /CS=1
8250 ASM X,ANDA #&HBF          :REM 0000 0XXX ACCA
8260 ASM X,ANDB #&HBF          :REM 0000 1XXX ACCB
8270 ASM X,STAB &H17           :REM /CS=0
8280 ASM X,STAA &H17           :REM 1st FALLING EDGE
8290 ASM X,STAB &H17
8300 ASM X,STAA &H17           :REM 2nd FALLING EDGE,ACCEPTS /CS=0
8310 ASM X,SLP                 :REM 42us USED OF 10ms

8320 L=X                  :REM A/D LOOP
8400 ASM X,LDAA &H60,X   :REM LOAD MUX,START OF A/D LOOP
8410 ASM X,STAA &H03           :REM MUX WORD
8420 ASM X,LDAA #&H86          :REM 1000 0110 BYTE INTO A/D
8430 ASM X,CLRB
8440 ASM X,PSHX
8450 ASM X,LDX #&H000C         :REM 12 BITS
8460 T=X                      :REM A/D SERIAL I/O LOOP
8470 ASM X,AIM &HF7,&H17       :REM CLOCK LOW,BIT LOOP
8480 ASM X,ASLD                :REM BIT TO CARRY
8490 ASM X,BCC A
8500 ASM X,OIM &H10,&H17       :REM "1"
8510 ASM X,BRA B
8520 A=X
8530 ASM X,AIM &HEF,&H17       :REM "0"
8540 B=X
8550 ASM X,TIM &H20,&H17       :REM READ Dout
8560 ASM X,BEQ C               :REM IF "0",WRITE NOTHING,
8570 ASM X,INCB                :REM ELSE STORE "1"
8580 C=X
8590 ASM X,OIM &H08,&H17       :REM CLOCK HIGH
8600 ASM X,DEX
8610 ASM X,BNE T               :REM LOOP

8620 ASM X,SEI                 :REM SET INTERRUPT MASK
```

```
8630 ASM X,OIM &H01,&H15    :REM START TIMING
8640 ASM X,OIM &H01,&H15    :REM P50=1,LENGTHEN PULSE
8650 ASM X,AIM &HFE,&H15    :REM P50=0
8660 ASM X,TIM &H04,&H15    :REM READ "BOTH REC" LAST VALUE
8670 ASM X,BEQ D

8680 ASM X,ORAA #&H80       :REM NOT REC,FLAG WITH SIGN BIT

8682 D=X
8684 ASM X,BITA #&H08       :REM CHECK FOR NEGATIVE
8686 ASM X,BEQ H

8688 ASM X,ORAA #&H70       :REM FILL OUT NEGATIVE

8690 H=X
8700 ASM X,PULX             :REM CONTINUE,IF"BOTH",DON'T FLAG
8710 ASM X,STD &H00,X       :REM STORE AT DATA,FIRST BOGUS
8720 ASM X,INX:ASM X,INX    :REM INCREMENT TWICE
8730 ASM X,TIM &H01,&H5E,X :REM CHECK FOR END OF LIST
8740 ASM X,BEQ E

8750 ASM X,CLI              :REM CLEAR INTERRUPT MASK
8760 ASM X,CLRA
8770 ASM X,STAA &H03        :REM PUT MULTIPLEXORS ON PARK
8780 ASM X,JSR &HFFD0       :REM CONOFF TURN POWER OFF
8790 ASM X,RTS              :REM EXIT FROM DIGITIZE ROUTINE

8800 E=X
8810 ASM X,LDAA &H17        :REM PREPARE TO RESPOND FAST
8820 ASM X,ANDA #&HE7
8830 ASM X,LDAB #&H02

8840 T=X                 :REM TEST LOOP
8850 ASM X,BITB &H15        :REM TEST A/D STROBE
8860 ASM X,BEQ T

8870 ASM X,STAA &H17        :REM HOLD WITH FALLING EDGE
8880 ASM X,CLI              :REM CLEAR INTERRUPT MASK

8890 ASM X,PSHX          :REM CONVERSION PART
8900 ASM X,LDX #&H0019      :REM 25,1st 2 FOR DEGLITCH
8910 ASM X,ORAA #&H40       :REM /CS=1
8920 ASM X,TAB
8930 ASM X,ORAB #&H08       :REM 0100 1XXX

8940 T=X                 :REM LOOP
8950 ASM X,STAB &H17        :REM 0100 1XXX
8960 ASM X,STAA &H17        :REM 0100 0XXX
8970 ASM X,STAB &H17
8980 ASM X,STAA &H17
8990 ASM X,DEX
9000 ASM X,BNE T            :REM 50 CYCLES,12x4+2

9010 ASM X,ANDA #&HBF       :REM 0000 0XXX
9020 ASM X,ANDB #&HBF       :REM 0000 1XXX
9030 ASM X,STAB &H17        :REM /CS=0
9040 ASM X,STAA &H17        :REM 1st FALLING EDGE
9050 ASM X,STAB &H17
9060 ASM X,STAA &H17        :REM 2nd FALLING EDGE
```

```
9070 ASM X,PULX
9080 ASM X,JMP L              :REM RETURN TO START

9100 X=&H73B0              :REM SUBTRACT AND TRANSFER SUBROUTINE
9110 ASM X,LDX #&H7400
9120 L=X
9130 ASM X,LDD &H02,X        :REM GET WORD
9140 ASM X,INX:ASM X,INX
9150 ASM X,BMI F              :REM TEST FLAG ON NORMAL MEAS
9160 ASM X,SUBD &H02,X        :REM DOUBLE SUBTRACT
9170 ASM X,TST &H02,X         :REM TEST FLAG ON REVERSED MEAS
9180 ASM X,BMI F
9200 ASM X,STAB &H02,X        :REM SAVE LOW BYTE
9202 ASM X,ASLA               :REM TEST FOR NEGATIVE
9204 ASM X,ASRA               :REM FILL WITH WHATEVER IT IS
9206 T=X
9210 ASM X,JSR &HFFD3         :REM STRMEM HIGH BYTE
9220 ASM X,LDAA &H02,X        :REM RECOVER LOW BYTE
9230 ASM X,JSR &HFFD3         :REM STRMEM LOW BYTE
9240 ASM X,INX:ASM X,INX
9250 ASM X,TIM &H01,&H60,X :REM CHECK END OF LIST
9260 ASM X,BEQ L
9270 ASM X,RTS                :REM EXIT
9280 F=X
9290 ASM X,LDAA #&H80         :REM FLAG MISSED RETURN
9300 ASM X,CLR &H02,X         :REM CLEAR LOW BYTE
9310 ASM X,BRA T

9900 RETURN

9999 END
```

```
/*  bin2mat - read Duck 10 /92 binary data files and output a MATLAB file of
        time /pressure /ldvNS / for each of 12 elevations (90 seconds each) * /

/*  jjfredericks Woods Hole Oceanographic Institution
        jfredericks@whoi.edu                 5 /93 * /
/*
        program reads for each of 12 elevations:

        a time in a 20 byte header
        a block of 90 seconds of data at 25 HZ (2250 values)
                as follows:
                1 byte ldvEW qualifier
                1 byte ldvEW velocity in counts
                1 byte ldvNS qualifier
                1 byte ldvNS velocity in counts
                2 byte pressure (in counts)
        these data are converted as follows:
                Time:
                        day /hour /min /seconds to day of month

                The EW LDV are ignored / were dealt with separately
                        as there were so few days with discernible data
                The NS LDV:
                        Counts -> cm /s as follows: ldvV = (129-ldvNS)*0.375;
                Pressure:
                        water depth = counts /(520*16*1.035)
                        where:
                                520*16 is the gain offset
                                1.035 is the conversion for fresh to salt H2O
                                        * /

#include <stdio.h>
#include "mat.h"  /* symbolic link to /usr /local /matlab /extern /...* /

#define MAXREC 2250  /* 25samples per sec * 90 secs * /

#define PGAIN  (double) (520*16*1.035)

#define VGAIN 0.375            /* ldvV axis gain for counts to velocity * /
#define VOFFSET 129            /* ldvV axis ofset in counts * /

/* for data set #1 something strange about time * /


char file_namein[40],file_nameout[40], temp[100];
int key;
FILE   *streamin, *streamout;

main(argc,argv)                                                          main
int argc;
char *argv[];
{
    int is,ir,j,i,ib, bytes, samps, chans, rcount,count,status,maxrec;
    double day,hour,min,sec,toffset;
/* 6750 is 25*90*3words /sample* /
    unsigned short dread1[6750],dread[10];

    double time[12],uqual,u,vqual[12][MAXREC],v[12][MAXREC],
                pressure[12][MAXREC];

    MATFile *fp;
    Matrix *a,*b;
```

```
/* rcount is the number of samples in each elevation * /
   rcount = 90*25;
   count=0;  /* block number * /
   samps = 12;
/* toffset for data set #1
   toffset = (double) (3.0+7.0 /24.0+38.0 /(24.0*60.0));
* /
/* toffset for data set #2 * /
   toffset = 0.0;

   fprintf(stderr,
          "\n\n\n TATTLETALE BINARY TO MATLAB BINARY CONVERSION    5/27/93\n\n");

    fprintf(stderr,"toffset: %f    PGAIN: %f\n",toffset,PGAIN);
    fprintf(stderr,"VOFFSET: %d    VGAIN: %g\n",VOFFSET,VGAIN);

   if (argc != 2) { fprintf(stderr,
          "\nUSAGE:   tt2mat filename_root\n\n");
          exit(1);
          }

   if (strlen(argv[1]) > 35) { fprintf(stderr,
          "Root name of file must be < 36 characters.\n");
          exit(1);
          }

   sprintf(file_namein,"%s.bin",argv[1]);
   sprintf(file_nameout,"%s.mat",argv[1]);

   if(   (streamin = fopen( file_namein, "rb" )) == NULL )
   {
      fprintf(stderr,
                      "\n\nFILE :%s: DOES NOT EXITS OR CANNOT BE OPENED",file_namein);
      exit( 0 );
   }

   if(   (streamout = fopen( file_nameout, "wb" )) == NULL )
   {
      fprintf(stderr,
         "\n\nFILE :%s: DOES NOT EXITS OR CANNOT BE OPENED",file_nameout);
      exit( 0 );
   }

  /* Read data and write to output file. Note: Different routine for
     for different values of "bytes".  * /
     for (i=0; i < samps ; i++)
     {
        ib=0;
         /* read 20 byte header * /
        status = fread( (char *) &dread[0], 2, 10, streamin );
        if (status != 10)
                     {   fprintf(stderr,
        "Error reading 20 byte header in samps %d nb = %d\n",count,status);
                      break;
                     }
        count++;
/* unpack time   -> days * /
        ir = 2;
        day = dread[2];
        hour = dread[3];
        min = dread[4];
         sec = dread[5];
        time[i] = day + hour /24.0 + (min+sec /60) /(24.0*60.0)+toffset;
```

```
            /* now read rest of data for this elevation */
            status = fread( (char *) &dread1[0], 2, 6750, streamin );
            if (status != 6750)
                    { fprintf(stderr,
                    "Error reading data block %d: nbytes read = %d\n",
                            count,status);
                    break;
                    }
            /* unpack */
            ir = 0;
            while(ir < 6750)
              {
              uqual = (double) (dread1[ir] >> 8);  /* 1byte uval */
              u = (double) (dread1[ir++] & 0x00ff);  /* 1byte uvel */
              vqual[i][ib] = (double) (dread1[ir] >> 8);  /* 1byte vval */
              v[i][ib] = (double) (dread1[ir++] & 0x00ff);  /* 1byte vvel */
              pressure[i][ib++] = (double) dread1[ir++] /PGAIN;    /* 2byte pressure */
              }
        }
    maxrec = ib;

    for (i=0;i<12 ; i++)
            for (j=0;j < maxrec;j++)
                    v[i][j] = (VOFFSET - v[i][j])*VGAIN;

    fclose( streamin );
/*  create and dump data to matlab file */
    fp = matOpen(file_nameout,"w");
    a = mxCreateFull(MAXREC,12,REAL);     /* REAL as opposed to COMPLEX */
    b = mxCreateFull(1,12,REAL);          /* REAL as opposed to COMPLEX */
     /* vqual */
    memcpy(mxGetPr(a),vqual,MAXREC*12*sizeof(double));
    mxSetName(a,"vqual");
    matPutMatrix(fp,a);
     /* v */
    memcpy(mxGetPr(a),v,MAXREC*12*sizeof(double));
    mxSetName(a,"v");
    matPutMatrix(fp,a);
     /* pressure */
    memcpy(mxGetPr(a),pressure,MAXREC*12*sizeof(double));
    mxSetName(a,"pressure");
    matPutMatrix(fp,a);
     /* time */
    memcpy(mxGetPr(b),time,12*sizeof(double));
    mxSetName(b,"time");
    matPutMatrix(fp,b);
     /* finished dumping to matlab file */
    matClose(fp);
    mxFreeMatrix(a);
}     /* End of Main Loop */
```

```
%
% joinlb - to join bin2mat ldv matfiles with bass matfiles
%
%  BASS matfiles were ascii files which were loaded and saved as matfiles
%        the processing of these data is done here ...
%
%        the bass offsets are:
%   A: -4.12    B: 2.39    C: 0.70    D: -2.59    (see zeros900 for exact values used)
%
%        the gain factor is:  (400NS /5000Counts)  /  1.33  NS /(cm /s)) /sqrt(2)   (cm /s per count)
%                        .                (0.0424 (cm /s) per count)
%
%        set ik before running (ik is the elevation id .. 1->12)
%     due to the 1.09 second offset of the BASS commencement of collection
%     the ldv and pressure are truncated (1:2250) -> (1:2200)  (2200 = 88*25)
%     the 10HZ BASS are interpolated to 50HZ and decimated ('fir') to 25 HZ then ..
%     the BASS are truncated as ........ (1:2250) -> (28:2227)
%
% jjfredericks - 5 /93 jfredericks@aqua.whoi.edu
%
%
clear i
load .. /d1205a /zeros900
%
for series=16:35
%for series=36:51
%eval(['load ../d1205a/d2b_0',num2str(series+1)])
eval(['load ../d1205a/d2b_0',num2str(series)])
eval(['load d21_0',num2str(series)])
vqual = vqual(1:2200,:);
v = v(1:2200,:);
pressure = pressure(1:2200,:)+1.0;
%
for ik=1:12
isam=(ik-1)*900 + 1;
m=isam:isam+899;
eval(['bass = d2b_0',num2str(series),'(m,:);']);
%
% unfold negative values
n=find(bass >32768);
bass(n) = bass(n) -2*32768;
%
jj = find(bass == 32768);  % index of flagged bad data
if (length(jj))
        display('BASS FLAG DATA IN series/eid:')
        display([num2str(series);num2str(ik)])
        display(num2str(length(jj)));
end
%
%
% subtract postcruise zeros for all 4 sensors
%  and multiply (240 /4095) /sqrt(2) -> components of E /W velocity (cm /sec)
vels = afact*(bass - pod);
%
% C-A -> E /W component pg60 jtrowbridge NB
% D-B -> N /S component "
hor = (vels(:,1) - vels(:,3)) + i*(vels(:,4) - vels(:,2));
vert = -(vels(:,1)+vels(:,2)+vels(:,3)+vels(:,4));
% convert to 25HZ for comparison with LDV/pressure
ubass = interp(real(hor),5);
ubass = decimate(ubass,2,'fir');
%
vbass = interp(imag(hor),5);
vbass = decimate(vbass,2,'fir');
```

```
%
clear i
wne(:,ik) = ubass(28:2227) + i*vbass(28:2227);
%
vert = interp(vert,5);
vert = decimate(vert,2,'fir');
w(:,ik) = vert(28:2227);
end
eval(['save ../bassldv/d2_0',num2str(series),' time pressure vqual v wne w'])
eval(['clear d2b_0',num2str(series)])
end
```

makeseries.m

```
%   to plot the joined DUCK data for report
%
% jfredericks@whoi.edu    5 /93
%
for series = series1:series2
sn = series-series1+1;
disp(series)
eval(['load d2_0',num2str(series)])
pm(:,sn)=mean(pressure)';
ps(:,sn)=std(pressure)';
%
wnew=wne;
degrees=-5.4;
rotate
wne = wnew.*thetar;
nbm(:,sn)=mean(imag(wne))';
nbs(:,sn)=std(imag(wne))';
ebm(:,sn)=mean(real(wne))';
ebs(:,sn)=std(real(wne))';
%vbm(:,sn)=mean(w)';
%vbs(:,sn)=std(w)';
%
for ic=1:12
nn = find(vqual(:,ic) >=128);
ng(ic,sn)=length(nn) /2200;
vmean = mean(v(nn,ic));
vm(ic,sn)=vmean;
vs(ic,sn)=std(v(nn,ic));
end
% check correlation of top-ldv with bass (NS)
nn=find(vqual(:,6) >= 128);
vbass6 = imag(wne(:,6));
nbmnn(1,sn)=mean(vbass6(nn));
nbsnn(1,sn)=std(vbass6(nn));
vbass12 = imag(wne(:,12));
ck=polyfit(vbass6(nn),v(nn,6),1);
slope(1,sn) = ck(1);
intcp(1,sn) = ck(2);
mse(1,sn) = mean(((v(nn,6)-vm(6,sn))-(vbass6(nn)-nbmnn(1,sn))).^2);
nn=find(vqual(:,12) >= 128);
nbmnn(2,sn)=mean(vbass12(nn));
nbsnn(2,sn)=std(vbass12(nn));
ck2=polyfit(vbass12(nn),v(nn,12),1);
mse(2,sn) = mean(((v(nn,12)-vm(12,sn))-(vbass12(nn)-nbmnn(2,sn))).^2);
slope(2,sn) = ck2(1);
intcp(2,sn) = ck2(2);
%
%
t(:,sn) = time';
%
end
%
%
sn1=series1;
sn2=series2;
eval(['save SS',num2str(series1),' pm ps nbmnn nbsnn nbm nbs ebm ebs ng mse slope intcp vm vs t sn1 sn2'])
sn1=1;
sn2=series2-series1+1;
```

```
% specdenl - to compute the mean of the spectral densities from S1 to S2
%                  by estimating the surface spectral density  from Pressure
%                  then, using known sensor heights, estimate the
%                  velocity spectral density
%          (See Section 5 of Nearshore Data Report (WHOI Tech 93:NN)

% load series of DUCK processed files and compute the Spectral Density
% load zeros900;d2l_NNN;d2b_NNN before running powerspec
% jjfredericks - 6 /93 jfredericks@aqua.whoi.edu
%  modified to take specden to 5Hz


M=1;
N = 2200;                   % length of time-series

dT   = 1 /25;               %time interval in time domain (fixed for 10Hz sampling)
dF = 1 /(N*dT);             % frequency interval in frequency domain
f=(0:(N /2)-1) /(N*dT);     % frequency vector with 20Hz sampling 0.055 to 1.0 Hz
f=f';
nf = find(f <= 5);

wsq = (2*pi.*f).^2;         % radian frequency
wsq(1)=0.000001;

% for frequencies 2 /90 to 90 /90;
prfftS = zeros((N /2),1);
prfftSV = zeros((N /2),1);

HS = 1.26                   % Height of pressure sensor
HB = 0.21;                  % Height of BASS sensor
HOFSET = 0.0;                % pressure offset to bring water column to 6 meters
G = 9.81;                   % gravitational force (m /sec^2)

khmin=-9;
khmax=9.0;
kh=khmin:0.01:khmax;
kh = kh';
whg = log(exp(kh).*tanh(exp(kh)));
length(whg)
tab1 = [whg kh];
clear kh whg
%
for series = series1:series2

eval(['load d2_0',num2str(series)])

for ik=1:12

% for each elevation create a 10Hz pressure time series

% process duck bass velocity to get u /v velocities (cm /sec)

        p25 = pressure(:,ik);                          % remove the mean
        disp('mean pressure')
        mp=mean(p25)
        ht = mp+HS+HOFSET;           % height of water column (p(m) + ht instrument)
        whg = log(wsq.*ht /9.8);
        lkh = table1(tab1,whg);
        kh = exp(lkh);
        K = kh. /ht;

        disp([num2str(series),num2str(ik)])
        disp('PRESSURE')
        var = (std(p25)).^2                   % compute the variance
```

specdenl.m

```
            prfft = fft(p25-mp);                    % compute the Fourier Series
            pS=prfft.*conj(prfft) /N*dT;            % compute the Spectal Density
            varcheck = 2*sum(pS(1:N /2))*dF         % check computation
            pS = pS(1:N /2);
            pX = (cosh(kh).^2). /(cosh(K*HS).^2);               % height of instrument (Z - H)
            pXS = pS.*pX;     % now I have Surface Spectral Density from pressure
% NOW convert this back to the Spectral Density of Velocity at .31m
%           to directly compare the two at 21 cm above bottom
            pV = ((pXS.*(cosh(K*HB).^2)). /(sinh(kh).^2)).*wsq;


%   compute spectral density & surface displacement spectra from cross-shelf

%   rotate BASS toward across-shelf orientation
            degrees = -10.0;
            rotate
            wne = wne.*thetar;

            west=-1.0*real(wne(:,ik));
            vm = mean(west);

% compute the variance (*100cm /m)
            disp('WEST BASS')
            var = ((std(west)). /100).^2
            prfft = fft((west-vm). /100);           % compute the Fourier Series
            pSU=prfft.*conj(prfft) /N*dT;                       % compute the Spectal Density
            varcheck = 2*sum(pSU(1:N /2))*dF                    % check computation
            pSU = pSU(1:N /2);

%   now for along-shore

            vm = mean(imag(wne(:,ik)));

% compute the variance (*100cm /m)
            disp('NORTHERLY BASS')
            var = ((std(imag(wne(:,ik)))). /100).^2
            prfft = fft((imag(wne(:,ik))-vm). /100);            % compute the Fourier Series
            pSV=prfft.*conj(prfft) /N*dT;                       % compute the Spectal Density
            varcheck = 2*sum(pSV(1:N /2))*dF                    % check computation
            pSV = pSV(1:N /2);

            pXSV = (pSU+pSV);


            prfftS = prfftS+pV;             % sum in preparation for averaging (pressure)
            prfftSV = prfftSV+pXSV;         % sum in preparation for averaging (velocity)
            M=M+1;
            end

end
%
%
M=M-1
pM = prfftS. /M;                        % complete averaging for Pressure
pMV = prfftSV. /M;                      % complete averaging for U+V
%
%
errors = log10((1+1.96 /sqrt(M)) /(1-1.96 /sqrt(M)))
%
```

joinseries.m

```
%  to plot the joined DUCK data for report
%
% jfredericks@whoi.edu    5 /93
%
% join the series into a long one and to plot it's histogram
%  looking at the BASS(all) BASS(nn) and LDV(nn) (NS only)
% modified to rotate the BASS 5 degrees westward of North(mag)
%          appears to be the orientation of LDV
%
%
vbass6=[];
ubass6=[];
vbass12=[];
ubass12=[];
%
vbnn6=[];
ldvnn6=[];
vbnn12=[];
ldvnn12=[];

nstart6=[];              % nstart = start of data for each series bass /ldv(nn6)
nstart12=[];             % nstart = start of data for each series bass /ldv(nn12)

t6=[];
t12=[];
t6all=[];
t12all=[];

nst12 = 1;
nst6 = 1;

for series = series1:series2
sn = series-series1+1;
disp(series)
eval(['load d2_0',num2str(series)])

% compute time series
gettime
t6all=[t6all;tseries(:,6)];
t12all=[t12all;tseries(:,12)];

degrees = -5.4;
rotate
wnew=wne.*thetar;

vb=imag(wnew(:,6));
vb=vb-mean(vb);
vbass6 = [vbass6;vb];
ub = real(wnew(:,6));
ub=ub-mean(ub);
ubass6=[ubass6;ub];

nn = find(vqual(:,6) >=128);
nstart6=[nstart6;nst6];
vb=imag(wnew(nn,6));
vb=vb-mean(vb);
vbnn6=[vbnn6;vb];
nst6=nst6+length(nn);
vl=v(nn,6)-mean(v(nn,6));
ldvnn6=[ldvnn6;vl];
t6 = [t6;tseries(nn,6)];

ub = real(wnew(:,12));
ub=ub-mean(ub);
```

```
ubass12=[ubass12;ub];

vb=imag(wnew(:,12));
vb=vb-mean(vb);
vbass12 = [vbass12;vb];

nn = find(vqual(:,12) >=128);
nstart12=[nstart12;nst12];
vb=imag(wnew(nn,12)); % remove the mean of only those samples!!!
vb=vb-mean(vb);
vbnn12=[vbnn12;vb];
nst12=nst12+length(nn);
vl=v(nn,12)-mean(v(nn,12));
ldvnn12=[ldvnn12;vl];
t12 = [t12;tseries(nn,6)];
end

clg
plot(vbnn6,ldvnn6,'.')
hold
plot(vbnn12,ldvnn12,'.')
XT=sprintf('D2_0%2d-0%2d (with mean removed)',series1,series2);
title(XT)
xlabel('NS-BASS (cm/s)')
ylabel('NS-LDV (cm/s)')
ck=polyfit(vbnn6,ldvnn6,1)
corrcoef(vbnn6,ldvnn6)
ck=polyfit(vbnn12,ldvnn12,1)
corrcoef(vbnn12,ldvnn12)
pause
axis([-50 50 -50 50])
axis('square')

sn1=series1;
sn2=series2;

nstop6=nstart6(2:length(nstart6))-1;
nstop6(length(nstart6)) = length(ldvnn6);
nstop12=nstart12(2:length(nstart12))-1;
nstop12(length(nstart12)) = length(ldvnn12);

eval(['save JR',num2str(series1),' vbass6 ubass6 vbass12 ubass12 vbnn6 vbnn12 ldvnn6 ldvnn12 nstart6 nstart12 nstop6 nstop12
sn1=1;
sn2=series2-series1+1;
```

```
% pfit4 - queries users to digitize and 'filter' sections of a line where real data is surrounded by noise
%         jjfredericks janet@mukilteo.whoi.edu   4 /93
%
%
% the sections are picked interactively using a viewport;
%                  then, the section limits are picked
% left button selects the limits
% right button exits loop
% middle button shows minimum processed section
%
x1 = 1;
x2 = 1;
xlook = 200;
%
istop = 1;
istart = 1;
%
while (x2 < 2250)

%plot EW-LDV all points (NAN where invalid data)
  figure(1)
  subplot(211)
  plot(ldv,'.');
  hold on

  aXis = axis;
  plot([istop;istop],[aXis(3);aXis(4)],'r');
  hold off

  disp('Select zoom range')
  [ic x1] = checkbutton(ldvtouch);
  if (ic)  break
           end
  [ic x2] = checkbutton(ldvtouch);
  if (ic) break
           end
  x2 = fix(max([x1;x2]));
  x1 = fix(min([x1;x2]));
  if (x2 > 2250)  x2 = 2250;
     end
  if (x1 < 1)  x1 = 1;
     end
  if (istart == 1)
           istop = x1;
           istart = 0;
           end

  figure(2)
  hold off
  plot(x1:x2,ldv(x1:x2),'.')    %plot the selected viewport
  hold on
  ist = x1;
  istop = x2;
  if (istop < x2 & istop > x1)
          figure(2)
           plot([istop;istop],[aXis(3);aXis(4)],'r')
           end
    ldvtouch(ist:istop) = ldvtouch(ist:istop)+1;

    figure(1)
    subplot(211)
    plot(ldv,'.')               %replot all data with limits
    hold on
    plot([ist;ist],[aXis(3);aXis(4)],'r')
```

```
        plot([istop;istop],[aXis(3);aXis(4)],'r')
        pause(1)
        hold off
        ldvtemp = ldv(ist:istop);

        figure(2)
%   hand-digitize curve
        [nj ldvj] = ginput;
        if(nj(1) < 1) nj(1) = 1;
            end
        if (nj(length(nj)) > 2250)   nj(length(nj)) = 2250;
            end

% get rid of duplicate x

        nn = find(diff(nj) == 0);
        if (nn)
            nj(nn) = [];
            ldvj(nn) = [];
            end

% make sure x is in ascending order
        [ns iord] = sort(nj);

        ldvfit = interp1(ns,ldvj(iord),ist:istop,'spline');

        plot(ist:istop,ldvfit,'-.');
        pause(1)

% accept only points +- 1cm /s from the fit through
%                                                    digitized points
        dldv = abs(ldvtemp - ldvfit);
        nfit = find(dldv < 1);
        ldvnew = NaN*ones(length(ist:istop),1);
        ldvnew(nfit) = ldvtemp(nfit);
        ldvn(ist:istop) = ldvnew;

        figure(2)
        hold off
        plot(ist:istop,ldvn(ist:istop),'o',ist:istop,ldv(ist:istop),'.')
        pause(1)
        figure(1)
        subplot (212)
        plot(ldvn,'.')
        title(num2str(ist))
end
```

```
% batch to recover some data points which may not pass spectral threshold
% procedure is to first find points which meet the test criteria for signal
% level and spectral validation; then using these, fit a polynomial and check
% if there are other data points in the intervening places which are within
% some small range of the valid points, nfit=# ofpoints fit in norder polynml.
%    yogi@zelda.nwra.com
%
% use
%          y=maxpoint(seg_data)

          function y=maxpoint(seg_data)
          y=seg_data;
   nfit=3;
   norder=2;
   hold off

   iv=find(seg_data(:,1)>127);
   v =seg_data(iv,2);
   mean_v=mean(v);
   std_v=std(v);
   vmax=mean_v+3*std_v;
   vmin=mean_v-3*std_v;
   iv=find(seg_data(:,1)>127 & seg_data(:,2)>vmin & seg_data(:,2)<vmax);

% now do running fit, try v first, use 10 points

%    l_iu=length(iu);
   l_iv=length(iv);
%  use nfit points for a polynomial fit
%  first do the v velocity then v
   loopend=l_iv /(nfit-1);

   for i=1:loopend-1
   is=i*(nfit-1)-1;
   ie=is+2;
   x=[iv(is):iv(ie)];
% is and ie are indices of raw data
   V=polyfit(iv(is:ie),seg_data(iv(is:ie),2),norder);
   pf(x)=polyval(V,x);
      for j=iv(is):iv(ie)
         diff=seg_data(j,2)-pf(j);
         if abs(diff)>=8
         seg_data(j,1)=0;
         else
         seg_data(j,1)=256;
         end
      end
   end

   ngood=find(seg_data(:,1)>127);

%clg
%subplot(2,1,1)
%        plot(seg_data(:,2),'.')
%hold on
%       plot(iv,seg_data(iv,2),'+m')
%subplot(2,1,2)
%       plot(seg_data(:,2),'.')
%hold on
%       plot(ngood,seg_data(ngood,2),'ob')
%       plot(iv,seg_data(iv,2),'+m')

         y=ngood;
```

APPENDIX C.

UTILITIES

These utilities are not included in the report. But, they are available and useful in viewing the archived files, as referenced in Section 7.

C-1. gettime.m - converts the instants of time ('time': 1x12) representing the beginning of each 88 seconds to a series of times ('tseries':2200x12).

C-2. settaxiss.m - relabels the time axes to human readable labels after plotting an 88 second record. E.g.,

```
plot(tseries(nn,12),v(nn,12),'.');
settaxiss(tseries(nn(1),12),Mode);
```

where mode=1, if annotations of year, month, day, hour, minute of beginning of axis is desired; or, mode=0, if no annotation is desired, only ticks; or mode=2, if only annotation of min:sec is desired. used in plotting statistical or joined data files.

C-3. settaxish.m - same as settaxiss (C-2); but, axis is in the 8-hour format.

C-4. settaxisl.m - same as settaxiss (C-2); but, axis is in the 20-hour format.

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16. Abstract (Limit: 200 words)

To provide observational data for analysis of near-bottom, wave-induced flows, a downward-looking laser Doppler velocimeter (LDV) was deployed to profile the near-bed velocity structure of a six meter water column at a site just outside the surfzone off the coast of North Carolina. 90 second "snap-shots" of the velocity at six elevations below 20 cm above bottom were measured at 25 Hz, while pressure was concurrently measured at 126 cm above bottom. The near-bottom data were supplemented with a benthic acoustic stress sensor (BASS) at approximately 20 cm above bottom which concurrently measured velocity components at 10 Hz. The purposes of this report are to document the collection, processing and archival of these data and to present the profiles for evaluation.

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